SALINE WATER CONVERSION

UNIVERSITY OF MICHIGAN
MAY 20 1958
MAIN READING ROOM

HEARINGS

BEFORE THE

SUBCOMMITTEE ON IRRIGATION AND RECLAMATION

OF THE

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS UNITED STATES SENATE

EIGHTY-FIFTH CONGRESS

SECOND SESSION

ON

S. J. Res. 135 and S. 3370

BILLS PERTAINING TO SALINE WATER CONVERSION PLANTS

MARCH 20 AND 21, 1958

Printed for the use of the Committee on Interior and Insular Affairs

UNITED STATES
GOVERNMENT PRINTING OFFICE
23642 WASHINGTON : 1958

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS

JAMES E. MURRAY, Montana, *Chairman*

CLINTON P. ANDERSON, New Mexico
HENRY M. JACKSON, Washington
JOSEPH C. O'MAHONEY, Wyoming
ALAN BIBLE, Nevada
RICHARD L. NEUBERGER, Oregon
JOHN A. CARROLL, Colorado
FRANK CHURCH, Idaho
GEORGE W. MALONE, Nevada
ARTHUR V. WATKINS, Utah
HENRY DWORSHAK, Idaho
THOMAS H. KUCHEL, California
FRANK A. BARRETT, Wyoming
BARRY GOLDWATER, Arizona
GORDON ALLOTT, Colorado

RICHARD L. CALLAGHAN, *Chief Clerk*
N. D. MCSHERRY, *Assistant Chief Clerk*
STEWART FRENCH, *Chief Counsel*

SUBCOMMITTEE ON IRRIGATION AND RECLAMATION

CLINTON P. ANDERSON, New Mexico, *Chairman*

HENRY M. JACKSON, Washington
JOSEPH C. O'MAHONEY, Wyoming
GEORGE W. MALONE, Nevada
ARTHUR V. WATKINS, Utah

GOODRICH W. LINEWEAVER, *Committee Assistant for Reclamation*
EUGENE D. EATON, *Consultant*

DEPOSITED BY THE
UNITED STATES OF AMERICA

CONTENTS

	Page
Senate Joint Resolution 135	1
S. 3370	1
Reports of Departments:	
Bureau of the Budget	5
Department of—	
Agriculture	2
Interior	3
Navy	6

STATEMENTS

Aandahl, Fred G., Assistant Secretary of the Interior, accompanied by David S. Jenkins, Director, and Joseph J. Strobel, chemical engineer, Office of Saline Water	24, 171
Badger, W. L., consulting engineer, Ann Arbor, Mich	75
Banks, Harvey O., director of water resources for the State of California	200
Brater, Eric R., assistant chief engineer, Cleveland Diesel Engine Division, General Motors Corp	151
Campobasso, John J., Badger Manufacturing Co., Cambridge, Mass	182
Case, Hon. Francis, a United States Senator from the State of South Dakota	12
Coit, Roland L., Westinghouse Electric Co	127
Eliassen, Rolf, consultant, New York City Water Authority, Cambridge, Mass	186
Engle, Hon. Clair, a Representative in Congress from the State of California	9
Gardner, William A., staff engineer, Griscom-Russell Co., Massillon, Ohio	97
Gilliland, E. R., president, and Dr. Walter Juda, executive vice president, Ionics, Inc., Cambridge, Mass	85
Hainsworth, William R., vice president, Research Division, Fluor Corp., Ltd., Los Angeles, Calif	159
Held, Dr. Kalman, TRG, Inc	207
Jenkins, David S., Director, Office of Saline Water	27
Kennedy, Harold W., county counsel of the county of Los Angeles, an attorney for the Los Angeles Flood Control District	54
Kuchel, Hon. Thomas H., a United States Senator from the State of California	15
Landry, Bertrand A., Battelle Memorial Institute, Columbus, Ohio	135
Larrecq, A. J., president, Power Generators, Inc., Trenton, N. J.; Eric R. Brater, assistant chief engineer, Cleveland Diesel Engine Division, General Motors Corp., Cleveland, Ohio; and Paul Pollock, Allis-Chalers Corp., Milwaukee, Wis	141
Lawaetz, Fritz, chairman, Public Works Committee, Virgin Islands Senate, accompanied by Donald Boreham	70
Maxim Silencer Co., Hartford, Conn	104
National Aluminate Corp	103
O'Leary, F. R., Maxim Silencer Co., Hartford, Conn., accompanied by W. R. Williamson	104
Resnick, Sol D., hydrologist, University of Arizona	215
Roosevelt, Hon. James, a Representative in Congress from the State of California	11
Rose, Dr. Arthur, professor of chemical engineering at Pennsylvania State College	195
Sandell, Dewey J., director of research, Carrier Corp., Syracuse, N. Y	183
Sulcer, Henry T., vice president and general manager, Graver Water Conditioner Co., New York, N. Y	198

DEPOSITED BY THE
UNITED STATES OF AMERICA

LETTERS AND TELEGRAMS

Page

Aandahl, Fred G., Assistant Secretary, Department of the Interior: Letter, dated March 28, 1958, to Senator Anderson, containing a review statement 181

Anderson, Senator Clinton P.: Letter, dated February 10, 1958, to Secretary Seaton 113

Avalon, Calif., Arthur L. Dow, city manager: Letter, dated February 17, 1958, to Senator Kuchel 18

Avalon Catalina Island Chamber of Commerce: Telegram, dated March 18, 1958, to—

Senator Anderson 68

Senator Kuchel 18

Badger, W. L., consulting engineer, Ann Arbor, Mich.: Letter, dated March 17, 1958, to Senator Anderson 79

Banks, Harvey O., director, water resources, State of California: Letter, dated April 25, to Senator Anderson, containing a resolution 225

Beasley, D. Otis, administrative assistant to the Secretary of the Interior: Letter dated April 1, 1958, to Senator Anderson 205

Bennett, Earl S., Agoura, Calif.: Telegram, dated March 18, 1958, to Senator Anderson 67

Beorse, Bryn: Letter, dated March 8, 1958, to Senator Anderson 213

Case, Senator Francis: Letter, dated June 6, 1957, to B. F. Childers 137

Chapman, Oscar, former Secretary of the Interior: Letter, dated March 25, 1958, to Senator Anderson 226

Childers, B. F., Edgemont, S. Dak.: Letter, dated May 4, 1958, to Senator Francis Case 136

Harvill, Richard A., president of the University of Arizona, Tucson, Ariz., Letter, dated March 13, 1958, to Senator Hayden, containing a statement by Sol Resnick 214

Howe, Everett D., professor of mechanical engineering, University of California at Berkeley, Calif.: Letter, dated April 10, 1958, to Senator Anderson 206

Knowland, Senator William F.: Letter, dated March 20, 1958, to Senator Anderson 51

Larrecq, A. J., president, Power Generators, Inc.: Letter, dated March 27, 1958, to Senator Anderson, containing exhibits 153

Mid-Coastal Counties State Water Plan Board, Santa Clara, Calif.: Telegram, dated March 19, 1958, to—

Congressman Charles M. Teague 52

Goodrich W. Lineweaver 68

Moore, Early W., Chowchilla, Calif.: Letter, dated March 20, 1958, to Senator Anderson 212

National Science Foundation, Washington, D. C., Alan T. Waterman, Director: Letter, dated April 21, 1958, to Senator Murray 225

Palm Springs (Calif.) Republican Assembly, Al E. Hoover, president: Letter, dated October 1, 1957, to Warren B. Francis, executive secretary, to Senator Kuchel, with an enclosure 18

Reams, Clinton August, consulting engineer, Reams & Scott: Letter, dated May 5, 1955, to Congressman John J. Bell 211

Santa Barbara (Calif.) County Water Agency, C. W. Bradbury, chairman: Telegram, dated March 17, 1958, to G. W. Lineweaver 68

Telegram, dated March 19, 1958, to Congressman Teague 53

Scott, E. Walter, consulting engineer, Reams & Scott, Box 7734, Washington, D. C.: Letter to Senator Anderson containing a description of the Reams process of desalination of sea water 209

Seaton, Fred A., Secretary of the Interior:

Letter, dated March 19, 1958, to Senator Anderson, expressing regret of his inability to appear personally at hearings 9

Letter, dated March 19, 1958, to Senator Murray, with enclosures from four Interior agencies concerned with saline problems 115

Sloane, P. M., Olympic Hotel, Los Angeles, Calif., American representative of Zarchins Inventions Exploitations Co. Ltd.: Letter, dated April 4, 1958, to Goodrich W. Lineweaver with an enclosure 212

Smith E. J., retired president, Calabasas Chamber of Commerce: Letter, dated March 17, 1958, to Harold Kennedy 57

Southwest Water League, 1361 Laveta Terrace, Los Angeles 26, Calif., Andrae B. Nordskog, president: Letter, dated April 10, 1958, to Senator Anderson 225

Page

Teague, Representative Charles M.: Letter, dated March 20, 1958, to Senator Murray, with enclosed telegrams 52
Tewksbury, Peter, Agoura, Calif.: Telegram, dated March 18, 1958, to Senator Anderson 67

ADDITIONAL INFORMATION

Analysis of brackish water at certain points in South Dakota 15
Brackish water experiments (tabulation presented by David Jenkins, showing projects underway) 36
Congressional Pressure Speeds Hunt for Fresh Water From the Sea (Article from Riverside (Calif.) Press-Enterprise 19
Ion Selective Membrane Research and Electrodialysis Engineering Development in South Africa (paper presented at the National Research Council by O. B. Volckman and W. H. Moyers) 45
Household Salt Water Purifier Developed (article by Tim Smith submitted by Senator Francis Case) 140
Reams process of desalination of sea water 209
Resolution adopted by the California State Legislature 65
Saline water demonstration plants and the Nation's water problem (speech by Senator Anderson on the Senate floor, April 1, 1958, in which he asks consent to add Mr. Case (South Dakota) and Mr. Kuchel (California) as sponsors of Senate Joint Resolution 135) 6
Sloane presents Israeli's sea water conversion to California city (newspaper article) 213

SALINE WATER CONVERSION

THURSDAY, MARCH 20, 1958

UNITED STATES SENATE,
SUBCOMMITTEE ON IRRIGATION AND RECLAMATION
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met at 10:10 a. m., pursuant to notice, in room 224, Senate Office Building, Hon. Clinton P. Anderson (chairman of the subcommittee) presiding.

Present: Senator Anderson.

Present also: Senators Kuchel and Case.

Senator ANDERSON. The Subcommittee on Irrigation will be in order.

At this point in the record I will order to be printed Senate Joint Resolution 135 and S. 3370, together with the reports of the departments on these bills.

(S. J. Res. 135, S. 3370, and the reports of the Departments of Agriculture and Interior, the Bureau of the Budget, and the Department of the Navy are as follows:)

[S. J. Res. 135, 85th Cong., 2d sess.]

JOINT RESOLUTION Providing for the construction by the Department of the Interior of a full-scale demonstration plant for the production, from sea or other saline waters, of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses

Resolved by the Senate and House of Representatives of the United States of America in Congress, assembled, That the Secretary of the Interior shall, pursuant to the provisions of the Act of July 3, 1952 (66 Stat. 328), as amended, and in accordance with this joint resolution, provide for the construction of a full-scale demonstration plant for the production, from sea or other saline waters, of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses, through the utilization of the ionic-membrane process, or one of the three most promising saline-water conversion processes currently under study in the Department of the Interior. A decision with respect to the process to be utilized in such plant shall be made by the Secretary within six months after the date of approval of this joint resolution, and the construction of such plant shall proceed as rapidly thereafter as is practicable.

SEC. 2. There are authorized to be appropriated such sums not in excess of $10 million as may be necessary to carry out the provisions of this joint resolution.

[S. 3370, 85th Cong., 2d sess.]

A BILL To amend the Act of July 3, 1952, to provide for the construction by the Department of the Interior of two pilot plants for the production, from sea and brackish waters, of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act entitled "An Act to provide for research into and development of practical means for the economical production, from sea or other saline waters, of water suitable for agricultural,

industrial, municipal, and other beneficial consumptive uses, and for other purposes," approved July 3, 1952 (42 U. S. C. 1951–1958), is amended by inserting at the end thereof a new section as follows:

"SEC. 9. (a) As part of the program authorized in this Act the Secretary of the Interior shall provide for the construction and operation of two pilot plants for the production of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses, through the utilization of the most promising saline-water conversion processes currently under study in the Department of the Interior. One such plant shall be located in the proximity of an ocean and shall be designed to treat sea waters and one such plant shall be located in the northern Great Plains and shall be designed to treat brackish inland waters. A decision with respect to the process to be utilized in each plant shall be made by the Secretary as soon as practicable after the effective date of this section, and the construction of such plant shall proceed as rapidly thereafter as is practicable.

"(b) The Secretary of the Interior is authorized to receive for the purposes of this Act such donations or contributions of funds, real and personal property as may be tendered by States, foundations, or individuals as in his judgment will be beneficial.

"(c) In addition to the sums authorized in, and without regard to the provisions of, section 8 of this Act, there are authorized to be appropriated such sums not in excess of $10,000,000 as may be necessary to carry out the provisions of this section, including necessary administrative expense."

DEPARTMENT OF AGRICULTURE,
Washington, D. C., February 19, 1958.

Hon. CLINTON P. ANDERSON,
Chairman, Subcommittee on Irrigation and Reclamation,
Committee on Interior and Insular Affairs,
United States Senate.

DEAR SENATOR ANDERSON: Your inquiry of February 6 pertaining to brackish irrigation waters was referred to the Agricultural Research Service, and they have responded with pertinent information.

There are 27 million acres of irrigated cropland in the 17 Western States. The prevalence of salinity and alkali constitutes a continuing hazard to crop production on about half of the acreage. On about one-quarter of this acreage, salinity and alkali are continuing to result in crop failures or uneconomic yields. For example, this problem is serious in the Imperial and San Joaquin Valleys of California, the Salt River Valley of Arizona, the Mesilla Valley of New Mexico, the lower Rio Grande Valley of Texas, the Arkansas Valley of Kansas, the Red River Valley of North Dakota, the San Luis and Gunnison Valleys of Colorado, the Snake River Valley of Idaho, the Yakima Valley of Washington, the Great Basin of Utah, as well as many other irrigated areas.

The United States Salinity Laboratory of the Agricultural Research Service is engaged in studying the salinity and alkali problems of the irrigated soils of the West. The scientists in this laboratory have developed and assembled an appreciable body of data on the subject and have published this information as Agriculture Handbook No. 60. A copy of this handbook is submitted herewith.

It is particularly germane to your question on the effects of brackish waters on soils that you refer to the digram on page 80 of this book. Thus, it may be seen that irrigation waters having an electrical conductivity above 750 micromhos/cm. carry a salinity hazard to crop production in the arid West. It has become conventional practice in the West to measure salinity of water in terms of electrical conductivity. Some people are more familiar with the terms "parts per million." The chart on page 71 shows that water with an electrical conductivity of 750 micromhos/cm. contains about 500 parts per million of dissolved solids.

This indicates that irrigation water does not have to carry very much dissolved salt to constitute a salinity hazard to the irrigated soils of the West.

Another point that must be kept in mind in judging the effect of water on soils is the content of sodium in the water with respect to calcium and magnesium. This consideration is called the sodium-adsorption ratio. As shown by the diagram on page 80, water carries an alkali hazard to soils (excessive exchangeable sodium) if the sodium-adsorption ratio (SAR) exceeds 10. Sea water has an SAR of 55. Sea water diluted to one-twentieth of normal concentration with no alterations in ionic proportions results in an SAR of 12.

The question immediately arises as to what alteration a given desalinization process would have on the initial ionic proportions in the water. There is a good possibility that the relative proportion of sodium would increase on desalinization. Such an effect would enhance the alkali hazard of the desalinized water to soil.

Agriculture Handbook No. 60 contains much technical information on the subject of your inquiry. If you have further questions concerning the technical data, qualified authorities in the Agricultural Research Service would be glad to discuss the subject further.

Sincerely yours,

TRUE D. MORSE, *Under Secretary.*

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D. C., March 19, 1958.

Hon. JAMES E. MURRAY,
Chairman, Committee on Interior and Insular Affairs,
United States Senate, Washington, D. C.

DEAR SENATOR MURRAY: This responds to your requests for the views of this Department on Senate Joint Resolution 135, a joint resolution providing for the construction by the Department of the Interior of a full-scale demonstration plant for the production, from sea or other saline waters, of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses, and S. 3370, a bill to amend the act of July 3, 1952, to provide for the construction by the Department of the Interior of two pilot plants for the production, from sea and brackish waters, of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses.

Senate Joint Resolution 135, if enacted, would authorize the Secretary of the Interior to construct a full-scale demonstration plant for the production, from sea or other saline water, of water which would be suitable for agricultural, municipal, and other beneficial uses. It would provide that the Secretary shall decide on the plant to be constructed within 6 months after the date of the approval of the joint resolution, utilizing either the ionic-membrane process or 1 of the 3 most promising processes currently under study in the Department of the Interior. The appropriation of not to exceed $10 million to carry out the purpose of the joint resolution would be authorized.

If it is enacted, S. 3370 would authorize the construction of 2 pilot plants at a cost of no more than $10 million, 1 such plant to be located near an ocean and be designed to treat sea water, and the other plant to be located in the northern Great Plains and to be designed to treat brackish water. It would also authorize the use of donations or contributions of funds or property for these purposes.

The act of July 3, 1952 (66 Stat. 328), authorized the appropriation of $2 million to enable the Department of the Interior to carry on, through contracts with private scientists and engineers, educational institutions, scientific organizations, and engineering firms, a 5-year research program looking to "the development of practicable low-cost means of producing from sea water, or other saline waters, water of a quality suitable for agricultural, industrial, municipal, and other beneficial consumptive uses * * *." This basic authority was amended by the act of June 29, 1955 (69 Stat. 198), to extend the life of the program to 10 years for active research with 2 additional years to complete existing research projects and 3 additional years to correlate data and publish results; to increase the maximum authorization for the program to $10 million, and to permit the expenditure of not more than $500,000 for research to be carried on in existing Government laboratories.

It is evident that the task of developing economically feasible saline water conversion processes provides one of the great challenges to American science. It is equally evident that the successful attainment of the objectives of this Department's saline water program will ultimately serve the expanding populations and new industrial empires of the world as few other achievements can do. Within our country, 21 of the 48 States border on the seacoast and contain more than 55 percent of our population and 65 percent of our industries. Furthermore, the scarce remaining supplies of fresh water in many of our inland areas can be augmented very substantially if the brackish waters there can be desalted economically. Both in America and elsewhere, successful

processes for conversion of sea or brackish water could render many water-poor areas productive and prosperous. Within friendly countries outside the United States, there are many regions lacking adequate sources of fresh water which might be supplied from desalted sea or other salty sources. Some of these areas are in the Middle East, north Africa, Latin America, Spain, Greece, Italy, Australia, and even in such countries as Iceland and Ceylon.

Certainly, the present program of research and development being carried out by the Office of Saline Water of this Department shows what can be done in this field and points the way to future potentialities of a continuing and broader effort. Our goal to the present time has been, and still will be, to encourage basic research and the exploration of various processes, some already known and others as they are discovered, in the development of means of producing large-scale facilities which will desalt and demineralize sea and brackish waters at the lowest possible cost. Most of the leading scientists in this field have joined wholeheartedly in this program. A good deal of laboratory study and research has already taken place and much progress has been made. We now have reached a point where several processes have been developed to the small pilot-plant stage and should soon enter the medium pilot-plant phase. In addition, 1 or 2 other processes which were already in commercial use in 1952, even though they involved high-cost operations, have been improved by their manufacturers. The Office of Saline Water of this Department is fully familiar with these processes and their potentialities.

From all of this, it is quite evident that the program initiated upon the passage of the 1952 act has now reached the stage where, as the next logical step, some sponsored research should be moving into more and more pilot-plant testing. To this extent, we believe that the purposes of S. 3370 indicate a consistency with the continuing aims of our saline-water program. Senate Joint Resolution 135 speaks in terms of a demonstration plant. As we interpret the phrase, not only in the sense in which it applies to scientific research and development programs but also in the possible understanding of the public, a demonstration plant would refer to any process which has been fully proven in all respects as the probable final development of the process and is ready to be demonstrated to the public as a final product. In contracts to this, the term "pilot" plant is generally considered to be a research facility with which further experimentation may be conducted in order to further improve the particular process.

It is very necessary that the present exploratory research and development program, devoted to the stimulation, advancement, and development of new ideas and approaches be retained and strengthened, and that the construction and operation of any pilot plant should not be interpreted to justify a narrowing of the approaches to a small number of processes. While we agree wholeheartedly that it is desirable to push forward on the more promising processes as rapidly as possible, it will be recalled that the Senate Appropriations Committee heard extensive testimony on April 17, 1953, to the effect that the research efforts should not be narrowed to 2 or 3 processes. However, we wish to emphasize that this new science of saline-water conversion is dynamic and growing. It is one in which this country is apparently well ahead of many others. One reason for this fact is the policy adopted by this Department of welcoming and exploring every new scientifically sound approach. This principle should not be altered by concentrating on one or two processes at this time.

Probably of equal importance is the fact that the Office of Saline Water of the Department of the Interior is the crossroads into which the ideas for improved processes constantly flow. The limited staff of competent scientists and engineers working in this Office receive and screen the ideas which are constantly reaching that Office. Combinations among processes now being developed separately by private organizations should also be considered to obtain the best practical developments at low cost. There is urgent need among individual organizations to produce an article for sale so as to repay development costs and earn a reasonable profit, oftentimes before the equipment has reached the optimum stage of development. Such processes are often improvements over competitive processes, but unfortunately, they fall short of the low-cost goals of our program.

Among the emerging potentialities for lower cost conversion is the use of low-temperature heat derived from nuclear reactions for use in saline-water distillation and other conversion plants. Initial calculations by competent engineering organizations have shown that such use of nuclear energy, without the expesive electric power generation cycle, may be of some advantage.

Suggestions have been made that cooperation between the Federal and State Governments on desalting research and demonstration plants be specifically

authorized. The present Saline Water Act already authorizes cooperation with any State and at this time the Department has under consideration such cooperation with the State of California.

The field of saline water conversion process developments is highly competitive and it is of the utmost importance that all contract and other negotiations with the public be given extremely careful consideration by completely competent technical personnel. One of the significant problems which has been encountered is the difficulty in obtaining the few highly trained and qualified scientists and engineers required to guide and manage the research and development program within the Department. To provide for an expanded scientific activity, or the entry upon a more expensive phase of development, it is necessary that sufficient funds be appropriated to carry out the work. In this connection, we believe it would be helpful to the committee to have the following schedule of requested funds and related appropriations:

Office of Saline Water

Fiscal year	Budget estimate	Appropriation
1953	$400,000	$175,000
1954	400,000	400,000
1955	400,000	400,000
1956	600,000	600,000
1957	600,000	550,000
1958	1,159,000	725,000
1959	825,000	[1] 785,000

[1] House allowance.

In view of all of the considerations herein discussed, it is our opinion that the Department may continue to proceed in this work in an orderly fashion and continue with the phase of pilot-plant development under existing authority without the enactment of further legislation such as Senate Joint Resolution 135 and S. 3370. At the very most it would appear that at some time in the future the status of the program may require an amendment of section 8 of the act so as to permit the undertaking of development activities which may extend beyond the time now permitted or which may require the appropriation of funds in excess of the present total authorization.

In the event the Congress should see fit to enact further legislation specifically authorizing pilot-plant operations, we suggest that such legislation should refer only to pilot plants and not to demonstration plants, and that the Secretary of the Interior should be authorized to determine where such plants should be located, when they shall be constructed, and what processes should be developed further by such activity.

The Bureau of the Budget has advised that there is no objection to the submission of this report to your committee.

Sincerely yours,

FRED G. AANDAHL,
Assistant Secretary of the Interior.

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D. C., March 21, 1958.

Hon. JAMES E. MURRAY,
Chairman, Committee on Interior and Insular Affairs,
United States Senate, Washington, D. C.

MY DEAR MR. CHAIRMAN: This is in reply to your letter of January 10, 1958, requesting the views of the Bureau of the Budget with respect to Senate Joint Resolution 135, providing for the construction by the Department of the Interior of a full-scale demonstration plant for the production, from sea or other saline waters, of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses.

The Department of the Interior, in the report it proposes to present to your committee on Senate Joint Resolution 135 and on S. 3370, a related bill, states that existing legislative authority is sufficient to permit orderly continuation of

the research program now being carried on by the Office of Saline Water, including the construction of pilot plants.

The enactment of Senate Joint Resolution 135 would in effect require a concentration of effort on only of the many saline water conversion processes now being studied. We do not believe that the program has yet advanced to the stage where such a decision can reasonably be made. Therefore, the Bureau of the Budget recommends against enactment of the joint resolution.

Sincerely yours,

ROBERT E. MERRIAM,
Deputy Director.

DEPARTMENT OF THE NAVY,
OFFICE OF THE SECRETARY,
OFFICE OF LEGISLATIVE LIAISON,
Washington, D. C., April 2, 1958.

Hon. JAMES E. MURRAY,
Chairman, Committee on Interior and Insular Affairs,
United States Senate, Washington, D. C.

MY DEAR MR. CHAIRMAN: Your request for comment on Senate Joint Resolution 135, providing for the construction by the Department of the Interior of a full-scale demonstration plant for the production, from sea or other saline waters, of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses, has been assigned to this Department by the Secretary of Defense for the preparation of a report thereon expressing the views of the Department of Defense.

The purpose of Senate Joint Resolution 135 is to direct the Secretary of the Interior to provide for the construction of a full-scale demonstration plant for the production of usable water from sea or other saline waters, using one of three conversion processes currently under study in the Department of the Interior. The resolution further provides that the Secretary of the Interior shall make the determination as to which process shall be utilized within 6 months after the date of approval of the resolution and authorizes an appropriation not in excess of $10 million.

The Department of the Navy, on behalf of the Department of Defense, defers to the views of the Department of the Interior. Although the bill imposes no duties or responsibilities upon the Department of Defense, a practical means of producing fresh water from salt water would be of great benefit to the armed services.

This report has been coordinated within the Department of Defense in accordance with procedures prescribed by the Secretary of Defense.

The Department of the Navy has been informed by the Bureau of the Budget that there is no objection to the submission of this report on Senate Joint Resolution 135 to the Congress.

Sincerely yours,

E. C. STEPHAN,
Rear Admiral, United States Navy,
Chief of Legislative Liaison
(For the Secretary of the Navy).

ADDITIONAL SPONSORS FOR SENATE JOINT RESOLUTION 135

(Senator Anderson subsequently directed that a statement he made on the floor of the Senate on Tuesday, April 1, relating to S. J. Res. 135, be inserted in the record of the hearings. The material is as follows:)

SALINE WATER DEMONSTRATION PLANTS AND THE NATION'S WATER PROBLEM

Mr. President, I ask unanimous consent that the distinguished junior Senator from South Dakota [Mr. Case] and the distinguished junior Senator from California [Mr. Kuchel] be added as cosponsors with me of Senate Joint Resolution 135 providing for the construction by the Department of the Interior of a full-scale demonstration plant for the production from the sea or other saline waters, of water suitable for agricultural, industrial, municipal, or other beneficial consumptive uses.

Hearings were held on the joint resolution on March 20–21 by the Subcommittee on Irrigation and Reclamation of the Senate Committee on Interior and Insular Affairs. I have the honor to be chairman of the subcommittee.

The hearings developed the urgency of the need for expediting demonstrations of the most economical processes for desalting sea water for the benefit of coastal cities where population and industry requirements for water are mushrooming. This is particularly true of southern California coastal cities.

No less pressing are the need for demonstrating the most economical means of treating brackish water in the Nation's interior areas for municipal, agricultural, and industrial uses.

We were somewhat taken aback by the unwillingness of the Department of the Interior and the Bureau of the Budget to recognize the need for early solution of the problems involved in demonstrating the most economical methods of turning vast water resources to potable uses. However, we believe when the facts developed at the hearings are read and digested, delaying tactics will be obliterated and greater support will come from all sources.

We expect early consideration of Senate Joint Resolution 135 by the Committee on Interior and Insular Affairs with a view to laying the problem before the Senate in the form of an amended resolution.

That the Senate may have a concise view of the Nation's water problem, I ask unanimous consent to insert at the conclusion of my remarks a tabulation prepared from official sources of past, present, and future water consumption in the several categories of major uses. The tabulation was prepared by the Corps of Engineers, United States Army, from a Department of Commerce report in 1956. The material referred to is as follows:

	United States population	Daily average per capita water use (gallons)			
		Industrial	Agricultural	Domestic	Total
1900	75,994,575	197	266	66	529
1910	91,972,266	223	424	75	722
1920	105,710,620	265	529	79	874
1930	122,775,046	321	490	89	900
1940	131,669,275	389	539	100	1,029
1950	150,697,361	560	664	124	1,348
1960	176,100,000	849	766	159	1,774
1970	196,300,000	1,074	810	177	2,061
1975	206,600,000	1,193	821	179	2,193

NOTE.—Computed from data presented in Department of Commerce Bulletin BSB-136 dated January 1956.

Senator ANDERSON. The hearing today and tomorrow was called to consider Senate Joint Resolution 135, which I sponsored, to authorize the Secretary of the Interior to provide for the construction and operation of a full-scale demonstration plant for the production, from sea or other saline waters, of water suitable for agricultural, industrial, and municipal or other beneficial consumptive uses.

In addition, we will also consider S. 3370, sponsored by Senator Case, of South Dakota, which has the same objective with one addition:

Senator Case would provide for a demonstration plant in the Great Plains area for the treatment of brackish water.

Senator Case, I mentioned the fact that we would consider your bill as well—S. 3370. I was in the process of saying I hoped you would be here as much as you could during the hearing, subject to your other commitment. I was hopeful that any final bill which would emerge would carry the suggestion which you have made for a plant in the Great Plains area for the treatment of brackish water.

Senator Case and I have been interested in weather modification for a long time, and we found that we were very much interested in this field, as well.

I am very hopeful that these two projects can work along together.

In announcing the hearings, in a news release, we stated that three subjects would be considered in connection with the problem that Senate Joint Resolution 135 seeks to tackle. These are:

1. Desalting sea water in sensitive coastal areas like Los Angeles, Calif., perhaps, in cooperation with State and local agencies.

2. Demineralization of brackish waters in the interior for irrigation, industrial, and domestic purposes.

3. Providing adequate potable water for the Virgin Islands, an insular American possession in the Caribbean, through a utilitarian multiple purpose sea water conversion plant.

In a letter to the Secretary of the Interior, Honorable Fred A. Seaton, on February 4 I outlined the scope of the hearings.

Previously, on January 10, Chairman Murray had requested formally a report on Senate Joint Resolution 135 from the Department and the Bureau of the Budget.

Subsequently, on February 10, I again wrote the Secretary outlining certain information which the Department was requested to provide on four fronts:

1. Office of Saline Water on its operations since the program was established in 1952—nearly 6 years ago.

2. Geological Survey on the Nation's water supply, uses, and needs.

3. Bureau of Reclamation with respect to effect of alkali and other minerals on irrigation water and the Federal investment in reclamation.

4. Division of Territories with respect to critical water problems on St. Thomas, V. I.

We had hoped to have this information so that it could be made available for perusal in a committee print before the hearings today.

In the absence of receipt of the material by March 8, when requested, a committee print was issued on March 14, outlining the scope of the hearings today and tomorrow. This committee print will be incorporated in the record by reference.

Secretary Seaton had advised us by letter that he would be present in person to present the Department's views on Senate Joint Resolution 135. Since he is from the West, is a former Senator, and a very good one, and former White House aide, we had loked forward to his appearance.

On Tuesday last, the Secretary phoned me personally from Nebraska to say that a change in his schedule made it impossible for him to be present today. He expressed deep regret and assured me of his intense interest in the saline water program.

He stated that Assistant Secretary Aandahl would present his personal views, as well as the official position of the Department.

We have had Governor Aandahl before the committee on other problems. He is former Governor of North Dakota and a former Member of the House of Representatives who knows western water problems.

I would put into the record at this point the letter of the Secretary of the Interior dated March 19, expressing regret that his personal requirements required him to go farther instead of returning to the East.

THE SECRETARY OF THE INTERIOR,
Washington, D. C. March 19, 1958.

Hon. CLINTON P. ANDERSON,
Chairman, Subcommittee on Irrigation and Reclamation,
United States Senate, Washington, D. C.

DEAR CLINT: Thank you for so graciously excusing me from my intended appearance before your subcommittee on March 20. As I told you when I called from Omaha yesterday, personal duty and travel commitments have risen which require me to be present elsewhere at the time you have your hearings on the saline-water program.

Assistant Secretary Fred G. Aandahl, will be present at the hearing with several members of his staff. In addition, I am informed that the Department's reports on the saline-water bills pending before your subcommittee have been cleared by the Bureau of the Budget and will be submitted immediately. The technical information you requested has already been mailed to the subcommittee.

Please be assured of my continuing interest and cooperation in this and other matters of mutual concern.

Sincerely yours,

FRED A. SEATON,
Secretary of the Interior.

In order that we may get the hearing underway, I emphasize this observation: In my opinion, a demonstrable solution to the saline and brackish water problem is the most important objective in the field of water development that has confronted this country since the enactment of the reclamation law in 1902.

Several bills relating to a saline-water demonstration program have been introduced in the House of Representatives.

I have a statement from the distinguished senior Senator from California, Mr. Knowland, which will be inserted later in the record.

(The document referred to appears on p. 51.)

I have a statement from the Honorable Clair Engle, chairman of the House Committee on Interior and Insular Affairs, which will be incorporated in the record at this point. He is the sponsor of H. R. 10606.

We have received a statement from the Honorable James Roosevelt, Representative from the State of California, which also will be placed in the record at this point.

(The two statements referred to are as follows:)

STATEMENT OF HON. CLAIR ENGLE, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. Chairman, I appreciate very much this opportunity to make a statement to your subcommittee on this very important legislation, to provide for construction of a demonstration plant to convert saline or salt water to fresh water. I am very much interested in the saline-water program, having authored the basic Saline Water Act of 1952 and the 1955 amending legislation. As you know, Mr. Chairman, I have introduced somewhat similar legislation in the House which I hope my committee will consider in the near future. I am sure that you and I are in full agreement with respect to the need for this legislation and the objective of advancing this most important research program. Therefore, I know that we can agree on final language which Congress will approve.

I congratulate you, Mr. Chairman, on your personal interest in the saline-water research program and on all that you have contributed to the program to date. I recall our discussions, Mr. Chairman, about 3 years ago in the conference committee considering an amendment to the basic Saline Water Act of 1952. We were both hopeful at that time that the amending legislation which we enacted would result in a speedup in this research program for finding ways and means of economical conversion of saline or sea water. Although progress has been made under this program, I have been disappointed that the results have not been more favorable. I had hoped for a breakthrough in the reduction of conversion costs but, after over 5 years of research under the Department's program,

no major breakthrough is indicated. It has become pretty clear that conversion of salt water for agricultural purposes will not be economically feasible for a long time. There is hope in the not-too-distant future of economical conversion of brackish water for agricultural purposes in some areas, and conversion for municipal and industrial use in areas that outgrow their available sources of supply, provided we move forward with a positive research and testing program.

In my opinion, the Department has not given this program the emphasis or the degree of urgency it deserves. Although it is true that we must make better and more efficient use of available water from natural sources before looking to salt water conversion, we must remember that in this field of water supply we must think in terms of expected needs 20, 30, or even 50 years in the future. There are areas where the exhaustion of available sources can be foreseen and in these areas the importance and urgency of speeding up this research program becomes obvious.

The question now is how to best advance the overall research program. While I believe that we should continue basic research in this field, it seems to me that the time has come when we should get into the "demonstration plant" phase with some of these processes. In this way, we could look to gradual cost reductions through improvement in efficiency, reductions in capital and operating costs, etc. I have come to this conclusion because there is no indication of any major breakthrough or sudden advance in technology which might bring about large reductions in cost of conversion. I am afraid that if we wait for an indication on such a major breakthrough, the critical water needs in some areas are going to catch us unprepared. It seems to me that the expenditure involved in this legislation is rather insignificant, considering that water is rapidly becoming one of the Nation's most important problems.

I noticed, Mr. Chairman, that one of the approaches listed in your announcement of these hearings related to desalting of sea water in coastal areas in cooperation with State and local agencies. I was particularly interested in this because it constitutes the major difference between your bill, on which these hearings are being held, and the bill I have introduced. In my opinion, the State of California has a greater interest in this program than any other State or area of the Nation at the present time simply becuse the water situation there is more critical and because California's future economy depends so heavily upon an adequate supply of water. The California Department of Water Resources has a special unit working in this field and several committees of the California Legislature are also studying the matter. For this reason, it seems to me that a joint venture between the Federal Government and the State of California would be appropriate, with the cost being borne equally between the two. I believe that the State of California is able and willing to join the Federal Government in this undertaking, and I expect complementary legislation to be introduced in the State legislature.

While my legislation is pointed more to large-scale conversion of sea water, I realize that conversion or demineralization of brackish water is just as important, especially in inland areas such as your State, Mr. Chairman. Since our research indicates that certain processes lend themselves to demineralization of brackish water, while others are especially designed for salt- or sea-water conversion, it would seem to me that the committee may want to consider authorizing demonstration plants in each of these fields.

With the tremendous and continuing increase in water needs in this country, and the growing dependence in many areas on the availability of water to maintain the economy, it seems to me that this program of finding ways and means of economically converting salt or saline water to fresh water is an urgent one. Critical water shortages already can be foreseen in some areas. It will take many years to construct and complete the testing of one of these demonstration plants after the construction is authorized, and, in my opinion, we cannot afford to wait longer in getting started in this phase of the saline water research program. Mr. Chairman, I want to make one point very clear. In pushing this program forward, we are looking to that time in the future when available natural sources of water have been exhausted in spite of our best efforts toward better and more efficient use thereof. Salt-water conversion cannot be considered as an alternative to developing available natural sources. The limiting cost factors involved in conversion make this very clear. Therefore, this research and testing program should not affect in any way the continuing studies and planning for development of our existing water resources.

I congratulate the committee and you personally, Mr. Chairman, for this positive approach to advancing this very important program. I will be interested in the testimony developed here and the committee's conclusions. I hope that legislation will be favorably reported. I hope also that the committee will give consideration to including authority for a joint venture between the Federal Government and the State of California and that you will spell out in some detail directions for the Department to follow.

Again, Mr. Chairman, I want to thank you for giving me this opportunity to make a statement.

STATEMENT OF HON. JAMES ROOSEVELT, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. Chairman and members of the committee, it is indeed an honor to have this opportunity to submit my views to you on the legislation before you—legislation which I believe to have not only compelling intrinsic value but also enormous potential for benefit to the water poor of the world. There can be no more desperate poverty than this. And, yet, the evidence is all around us that water, that resource so precious that it has determined the very course of civilizations, is in cold fact in such short supply that in some areas in this country water famine is almost inevitable.

As a nation, we consume 250 billion gallons of water a year. It is estimated that by 1975 our water consumption will have doubled. The director of the Department of Water Resources of California estimates that unused water resources necessary to support the southern part of the State will last 8 to 10 years. Southern California is not unique. Areas on the east cost, the gulf coast, and wide stretches of the interior face the same threat. The thousand communities which last year were forced to ration water are ample evidence that the forerunner of the threat is with us now.

We must face the inescapable fact that water as a national resource is not limitless, as it once appeared to be. And we must further face up to our responsibility to do something now to prepare for the day when we will be forced, whether we like it or not, to meet the crisis of water shortage. While an effective program of conservation and water reuse is a vital basis for a long-term solution to the problem, it seems clear to me that supplementary water sources to those now found naturally are urgently needed.

The resolution now before you offers, in my opinion, the most realistic, practical, and even exciting answer to the question of what to do to develop new, untapped water sources. Because I believe so strongly that the conversion of saline water to fresh water is the answer, I have introduced in the other body a resolution substantially the same as that of Senator Anderson, and for the same purpose.

I have done this, and appear before you today, because I believe that we have now had ample demonstration that saline-water conversion is an operating fact, not only on the basis of pilot projects which have grown out of laboratory research, but in growing parts of the world as an economically feasible method of supplying water.

We know that at Kuwait, on the Persian Gulf, distillation plants are daily converting 5 million gallons of high salt content sea water to fresh water. Elsewhere in scattered parts of the world the miracle of pure water from the sea is taking place. And in an area that is water-starved, the impact of machines that will turn out pure water to replace the sparse, semibrackish natural supply can be enormous.

Apart from our own water needs, it is those areas of the world which are in the most crucial positions in the battle for favor between East and West that coincidentally stand to benefit most from a practical method of converting saline water. We are spending millions on our foreign-aid programs in the Middle East and are continually engaged in an almost desperate search for means to establish and cement pro-Western attitudes in this vital part of the world. So far our success has been less than overwhelming. If, however, we can put into operation in this country large-scale water-conversion plants, utilizing the best methods that have so far been developed, we can demonstrate to the world that the United States is putting its technology behind a program that can truly be applied to the welfare of the people themselves. The down-to-earth impression that an American "wetnick" would make will far outshadow the glory that sputnik garnered for Russia.

23642—58——2

In urging a favorable report for this measure I do not mean to imply that the research and development phase of saline water conversion should be considered ended. Far from this, I believe that the work of the Saline Water Department must be continued and augmented at this basic level, in order to guarantee the broad foundation that will continue to develop and improve the product, or culmination of the research program.

I would like to take this opportunity to submit to the committee that they consider, in addition to the establishment of demonstration plants, studies in connection with the plants to evolve the most practicable methods for the distribution of water once it is produced. Saline water conversion is a unique method for producing water in the quantity which this resolution assumes, and I believe will give rise to unique distribution problems that must be realistically met.

If these two matters can be considered together, I believe that the passage of Senator Anderson's resolution will mark the beginning of a vast expansion of our economic potential, be a contribution to the solution of our economic problems, and forge yet another link in the contribution of our country to the peaceful welfare of mankind.

Senator ANDERSON. Senator Case, we are happy that you are here this morning. If you have a statement, I will be pleased to have you as the first witness.

STATEMENT OF HON. FRANCIS CASE, A UNITED STATES SENATOR FROM THE STATE OF SOUTH DAKOTA

Senator CASE. Mr. Chairman, I do appreciate the opportunity to be here and participate in these hearings with you on Senate Joint Resolution 135 and S. 3370.

As I told you when I saw you on the Senate floor one day, I was going to plagiarize a little bit from your bill and use it as a foundation for putting in an addition for the purpose of getting actual operating plants large enough to give us the information necessary for the translation into practical field operations of the desalting equipment.

The bill which I introduced is supplementary, you might say, to yours. I thought of approaching it by making an amendment to the basic water act and to make clear that the administrative funds available to that unit within the Department of Interior would be available for working on this plant development.

That is perhaps a little technical. The principal addition I wish to make was to provide authority for establishing a plant in the inland areas where it could deal with brackish waters such as are found in the Great Plains country, particularly the northern Great Plains.

The amount of water or the seriousness of the problem perhaps is more apparent where you have coastal cities, but for the people who live in the Great Plains area where they have alkali or brackish water, it is a very real problem, although perhaps not affecting in any one place as many people as in the large cities.

I think for the purpose of this hearing and for the benefit of the people present, I need say nothing in regard to the importance of finding new sources of supply of water.

Our use of water has quadrupled since the turn of the century while our population has been doubling.

So on per capita basis we are using at least twice as much water per capita and with the increasing population we have a water demand four times what we had at the beginning of the century. That means that we have to take new sources.

In addition to that, we have different types of needs. So that the problem grows in importance every year.

Senator ANDERSON. Would you not say, Senator Case, that there is hardly any facet of our present life that does not call for additional supplies of water? We put in air-conditioning units and start using more water. We develop all sorts of new devices in our homes, dishwashers, garbage-disposal units; they all use water.

We face not only the great population increases which seem to be ahead of us, but we face the fact that each one of these people will use far more water than the past generation used.

I am glad that you have mentioned the fact that these people who live in the Great Plains area, particularly the northern Great Plains, may not use as a great municipality located in other parts of the country, but their need is just as great and to them it is as serious a problem as any other.

Go right ahead.

Senator CASE. The Government itself has a considerable stake in this matter because many of its projects which store water today are faced by the problem of a growing salinity as the water is used in connection with certain soils.

Of course, in my State we have had the experience where one large dam was constructed, was completed some years ago, but the intended use of it is handicapped because of the fear that it carries some salt and would leach out others on the land to which it would be applied; so it has not been returning to the Government the benefits that were expected or anticipated when it was built.

Another project was stopped before the dam was built, but after a considerable amount of money had been spent.

I am not criticizing the Bureau of Reclamation for stopping work on that dam. It probably was wise not to proceed with the second dam until we knew some solution to the water problem, but it does mean that we have made investments where the returns would be increased if we had an answer to the water problem.

Just because I think it may be a bit of a shock to some of the people present, I brought along the analysis of a few wells in the northern Great Plains area to show what we mean when we speak about brackish water. I have a sample of one well, for example, where the analysis was made by the South Dakota School of Mines and Technology at Rapid City, S. Dak.

The water came from out on the prairie some 60 or 70 miles east of Rapid City. The total dissolved solids were 6,000 parts per million.

The grains per gallon were 349.98.

The hardness was 121.50.

The sodium chloride in parts per million was 130.3.

Sodium sulfate, 2,868.4.

Calcium sulfate, 1,749.1.

Magnesium sulfate, 483.9.

Magnesium carbonate, 332.6.

Iron—that is, ferric oxide—0.5.

Silica, 26.

Volatile and organic matter, 409.2.

Making total dissolved solids, 6,000.

On the grains per gallon the sodium chloride was 7.60.
Sodium sulfate, 167.31.
Calcium sulfate, 102.02.
Magnesium sulfate, 28.23.
Magnesium carbonate, 19.40.
Iron, 0.03.
Silica, 1.52.
Volatile and organic matter, 23.98.

That, I think, is a factual illustration of the kind of hardness and the kind of salts that do exist in these waters.

Yet with the plant that was placed in Miller, S. Dak., a few years ago under the experimental program which the Department conducted I saw the plant in operation and tasted some of the water which went through the plant.

Two-thirds of the water put into it came out as salt-free water. One-third of it carried away the sludge.

The water which came out from that—that is, using the ionic process—the water that came out was palatable and easy and safe to drink.

Senator ANDERSON. It had been pretty bad previously?

Senator CASE. I can supply that for the record.

The actual analysis of Miller water, I have it in here and will supply that for the record, Miller was selected by the State board of health as representative.

It was not the worst nor was it the least in salt content, but it was selected as an average community and they estimated there that if they could get a practical means of desalting the water it would mean a great saving to the city itself as well as to the people in heating plants and in the use of detergents and other softeners that people in the homes were required to use.

That would be true of a great many towns and cities in the northern Great Plains as well as the farms and ranches. That is why I hope that as the committee proceeds in the consideration of this idea which you have suggested, that we will include a plant in the Great Plains area as well as one on the seacoast.

I thank you, Mr. Chairman.

I might want to submit some further material or letters for the record, and I hope I have your permission to insert them.

Senator ANDERSON. We will be very glad to have them.

(Senator Case subsequently submitted the following:)

PREPARED STATEMENT OF SENATOR FRANCIS CASE

The growing needs for water in this country point up the importance of finding new sources of supply. There is no question but that our normal water resources are diminishing or being contaminated and we must find new ways of supplying water to fill the demands made by our growing population.

When the Congress passed the Saline Water Act in 1952, we provided the necessary research program to study and evaluate the methods of converting sea water and brackish water to beneficial uses. Probably no program ever entered into by the United States Government holds the promise of so many benefits for so little investment.

Seacoast cities that are faced with the need to supply water for expanding industrialization would have to look no farther than the sea for their water supplies. The program will help to solve the problems of the small towns that have iron, magnesium, or sulphur in their water supplies and give thme a potable supply. The program offers hope to the rancher living in an area where the only well water he can get is alkaline and brackish, and is poor water for

his stock and for his family. Parched desert lands, not only in this country, but also in arid countries abroad, could be reclaimed.

The cost of converting sea or brackish water must be lowered considerably before converted water can compete with the maximum prices now paid for natural fresh water. To attain this objective, we must keep our program of research going forward.

Mr. Chairman, we have reached the point in saline water research where it is time to replace exploratory research in the laboratory with pilot-plant operations and field testing of the more promising processes.

No one appreciates more than I do, Mr. Chairman, the support you and this committee have given to research and development in conversion of saline and brackish water. I was made more than happy with your introduction of Senate Joint Resolution 135, which would authorize a full-scale demonstration plant for the production from sea or other saline waters of water suitable for beneficial consumptive uses.

The saline water conversion program has benefits for all sections of the country and that is why I introduced S. 3370. My bill would provide for the construction of 2 pilot plants, 1 to be located in the proximity of an ocean and designed to treat sea water. The other would be located in the northern Great Plains and designed to treat brackish waters.

The problem of providing adequate water supplies is not limited to any particular section of the country and it seems to me that we ought to provide the demonstration plants not only for the areas along the coast, but also for our inland areas.

(The following analysis was submitted by Senator Case:)

ANALYSIS OF BRACKISH WATER AT CERTAIN POINTS IN SOUTH DAKOTA

Miller: 1,800 parts per million, with 200 parts per million hardness
Midland: 2,400 parts per million
Britton: 2,600 parts per million
Redfield: 2,200 parts per million
Pierre: Special problem of 26 parts per million of manganese which precipitated in cast-iron water mains and plumbing and discolors masonry
Newell: 1,581 parts per million, of which 256.9 is calcium and 934.7 is in sulfate (calculated hardness as $CaCO_3$ is 934.4 parts per million, with 100 to 150 the recommended)

Senator ANDERSON. I see the junior Senator from California is here.

Senator Kuchel, do you have any comments you would like to make.

STATEMENT OF HON. THOMAS H. KUCHEL, A UNITED STATES SENATOR FROM THE STATE OF CALIFORNIA

Senator KUCHEL. Yes, Mr. Chairman.

First of all, I want to say that the respect I have for the chairman personally and officially has been enhanced by his leadership in what could be one of the most romantic and far-reaching developments that this country and its economy may ever realize. I can remember the chairman in this committee on many occasions in the past 6 years speaking of the possibility of bringing to the people of this country and to the world water from the sea which would be potable and which might well be accomplished more rapidly through the use of atomic energy, a subject with which the chairman has been intimately acquainted through his chairmanship and his membership of the Joint Atomic Energy Committee.

I have some additional comments here which will not take too long which I would like to read into the record.

The steady and phenomenal growth of population in my own State of California, with the expansion of industry in many sections which

were formerly rural or agricultural in character, has continued to provoke alarm about the possibility of running out of water.

I need not indicate the basis for that widespread apprehension except to say that it is ever present.

It is a reasonable one, and I think it grows more alarming as we continue to receive each year about 500,000 additional new citizens.

The estimate of future requirement have prompted consideration of a variety of measures, notably the complex and arduous long-term California water plan which, as the chairman knows, will envisage ultimately a cost to the people of California of approximately $11 billion.

While alert and responsible agencies and communities are making or carrying out concrete plans to improve and expand their present water supplies, the great hope is felt that a practical process of converting ocean water can be developed in time to avert threatened shortages and acute overdraft situations.

Constituents in many parts of my State have urged me, both as individuals and in their official capacities, to support the present research and development experimentation efforts being carried on by the Department of the Interior under the law enacted by the 84th Congress which, of course, along with the chairman, I was most glad to support.

There are even today a number of critical situations in my State where the method of distilling or otherwise converting ocean water could bring immediate relief, notably among these is the city of Avalon on Catalina Island. The steady decline in the water level in that community storage reservoirs has brought a real state of emergency with real restrictions and virtual rationing of water.

The problem is so real and apprehension for the future so great that the head of the city government has written to me urging that a pilot plant if at all possible, be constructed on his whole island of Catalina where dual benefits could be realized from further experimentation in this field.

The interest and degree of hope in California is so lively that a few years ago the city of San Diego, which for years has been plagued by an inadequate supply, on account of a prolonged drought and also at a time of steadily increasing population, offered a site to the Federal Government for a pilot plant in which field tests of solar distribution method might be conducted.

For various reasons, although a lease of low rental was negotiated, nothing ever came of this effort to speed up research and experimentation program.

In a number of areas in California along the Pacific coast, the salt water intrusion of underground water reservoirs has become a serious problem. Here, once again the chairman will remember that the legislation which I introduced, which I am most grateful, the chairman took the lead in obtaining the recommendation of the committee, provided for the construction by the Federal Government of a dam in Ventura County became law, that dam is now under construction and it has averted the hazard that the people of that great county in my State constantly faced, of salt water intrusion into both the domestic water supply and also the farm area there.

Instances of the souring of wells have been reported with increasing frequency in the coastal plain between Los Angeles and San Diego.

As the Irrigation and Reclamation Subcommittee was told earlier, I think this week a similar situation exists, up the coast, in Monterey and San Benito Counties and large metropolitan area in Santa Clara County.

There are instances of shortages so acute that water is brought in in tank cars.

The city of Coalinga does not exist except by the trucking in of water which permits the people in that small community and the San Joaquin Valley to continue living.

The inadequate supply and ever growing demand at Santa Barbara was sufficient in recent years, was serious enough, to warrant pushing of the Cochuna project. That community and others in our State had been required to adopt local ordinances, city and county law, by which restrictions were applied in the use to which water might be put.

The feeling of a good many people in California probably is typified by a comment from a letter I have received from a civic leader last fall who wrote to me in protest against what he termed—

> The false economy of Congress on cutting down on the most vital project in the United States today.

He referred to the saline water program for which funds last year were cut over $400,000.

A few months ago one of our national news services distributed a feature story about the hunt for salt water from the ocean. This story was played up prominently from newspapers from one end of California to the other and provoked considerable editorial comment. I cite this as an example of the lively interest in our State on this program.

Already considerable use of ocean water is being made for certain industrial operations in my State, but on a limited scale. One of our big public utilities has resorted to a system of converting salt water for a generating plant in order to serve an area where fresh water is not otherwise readily available.

However, in such instances cost is high and only exceptional circumstances warrant such operation.

The laboratory experiments so far reported appear to justify moving forward to field tests and demonstrations on a large scale.

If the economics of saline water conversion are to be ascertained, it is imperative to construct a pilot plant such as is proposed in the pending legislation.

I ask the chairman for consent to file with the record a telegram I have received from the Avalon, Catalina Island, Chamber of Commerce and a copy of a letter which the city manager of that community has written to me.

May I also ask that at this point in the record there be included a letter from the Palm Springs Republican Assembly with an enclosure from the Riverside (Calif.) Press, which I ask be printed in full.

Senator ANDERSON. Without objection, they may be placed in the record at this point.

(The material referred to follows:)

TLELGRAM FROM AVALON, CATALINA ISLAND, CHAMBER OF COMMERCE

AVALON, CALIF., *March 18, 1958.*

THOMAS KUCHEL,
Senate Office Building, Washington, D. C.:

We strongly urge favorable consideration of bill H. R. 11405, any other plan to locate pilot salt water conversion plant on Santa Catalina Island. Unique island location will eliminate local rivalaries inevitable if mainland location chosen. Value of water produced will be greater here. Ideal environment for project of experimental nature. Need here is immediate. Southern California peak shortage years in future. We strongly urge consideration on its merits of locating a salt water conversion plant on Catalina Island.

AVALON CATALINA ISLAND CHAMBER OF COMMERCE.

TELEGRAM FROM THE CITY OF AVALON, CALIF.

CITY OF AVALON,
Avalon, Calif., February 17, 1958.

Hon. THOMAS H. KUCHEL,
United States Senator,
Senate Office Building, Washington, D. C.

DEAR SENATOR KUCHEL: The city of Avalon, Calif., is faced with a critical shortage of fresh water, which is the lifeblood of this city. Avalon's very existence depends on tourist trade, and without water there will be no tourists. Water level in the storage reservoir, in the hills, has been dropping steadily for the past 2 years. At the present time, the level is 15 feet below normal; and the city is now operating under an emergency conservation ordinance, allowing 50 percent of normal consumption.

The city council, at its last regular meeting held on February 6, 1958, requested the city manager to write a letter to all county supervisors, State and Federal legislative officials, calling attention to Avalon's water needs and respectfully recommending that a pilot plant for the conversion of salt water to fresh water be located here on Catalina Island in the city of Avalon. This would not only help the city of Avalon but would produce vital information for all parts of the country faced with a water shortage. It is hoped that all concerned will give this matter careful and favorable consideration.

Thanking you for your interest and courtesy, I am,

Yours very truly,

ARTHUR L. DOW, *City Manager.*

LETTER FROM PALM SPRINGS (CALIF.) REPUBLICAN ASSEMBLY

PALM SPRINGS REPUBLICAN ASSEMBLY,
Palm Springs, Calif., October 1, 1957.

Mr. WARREN B. FRANCIS,
Executive Secretary, Senator Thomas H. Kuchel,
Senate Office Building, Washington, D. C.

DEAR MR. WARREN: Please find enclosed clipping from Sunday's Riverside Enterprise (this appeared in Los Angeles Times same day) on the very subject I wrote to the Senator about: the false economy of Congress on cutting down on the most vital project in the United States today.

I wish you would bring this to the attention of the Senator and let him know how we feel about this on the desert.

Yours sincerely,

AL E. HOOVER, *President.*

[From Riverside (Calif.) Press-Enterprise, September 29, 1957]

CONGRESSIONAL PRESSURE SPEEDS HUNT FOR FRESH WATER FROM SEA

By Roger Greene, AP Newsfeatures Writer

WASHINGTON.—All over the world, man is struggling to realize his ancient dream of making the deserts bloom by unlocking fresh water from the salty seas.

At last—spurred by drought, booming population and vastly expanding industrial usage—American scientists may be approaching the outer threshold of success.

There is no secret about converting salt water to fresh. The sun does it every day, vaporizing billions of tons of sea water and lifting it into the clouds * * * then returning it to the earth in the form of rain. Man finds it more difficult.

Past civilizations have risen and fallen according to their water resources. The Assyrians and Babylonians flourished in the once lush Tigris-Euphrates Valley, then vanished when the climate changed and the drought-scourged land turned to desert wastes.

With our needs growing very year, experts say the same thing could happen here, unless new sources of water are found. Almost every year more than 1,000 United States cities and towns are forced to restrict water usage in dry spells. In Dallas, jugged water sold for 50 cents a gallon during the drought early this year.

Warned of the impending danger, Congress in 1952 set up an Office of Saline Water (OSW) in the Interior Department and authorized a multimillion dollar program to develop economical methods of converting salty or brackish water into fresh water.

Patiently sifting through literally hundreds of proposals, the agency has yet to come up with a final answer.

Congressional critics, irked at what they regard as slow progress, have scolded Interior Department officials for issuing rose-colored predictions unsupported by evidence of a major breakthrough in 5 years.

A House committee, summing up the testimony at recent hearings, said in its official report:

"The committee concludes that we still have a long way to go before general use of converted sea water becomes a reality and suggests to the Secretary of the Interior that, in these days when water is becoming more and more critical in many parts of the Nation, there is a danger of raising false hopes * * *."

In many countries—England, Spain, Israel, Yugoslavia, French Morocco, South Africa, Italy, Australia and elsewhere—top research teams are trying to solve the riddle.

Scientists know the answer within limits. The rub is how to do it cheaply enough to compete with the price of natural fresh water from rivers, lakes and streams.

Where cost is not the controlling factor, huge conversion plants are already producing millions of gallons of desalted water daily.

United States Navy ships have been distilling their own water from the sea for more than 40 years. The superaircraft carrier *Saratoga*, for example, produces 60,000 gallons a day for shipboard use.

In the little oil-rich kingdom of Kuwait, on the Persian Gulf, United States-built sea water evaporators can turn out 5 million gallons of fresh water a day. On the Dutch island of Aruba, the site of great oil refineries off the coast of Venezuela, similar units distill 3 million gallons daily. These two are the largest ever constructed.

In the United States, the Pacific Gas & Electric Co. has spent over $44 million on a plant at Morro Bay, Calif., to convert ocean water into fresh water for its giant steam boilers. It has a capacity of 144,000 gallons a day.

Even at a cost of $1.95 per 1,000 gallons for the converted water—compared with 25 cents a thousand for San Francisco municipal water—the company figures it is cheaper to distill sea water than to sink wells or build dams.

But the average United States householder, accustomed to paying about 30 cents a thousand gallons for water to drink, wash dishes, and sprinkle his lawn, would shudder at the thought of paying $1.96. So would the farmer who now pays around 12 cents per 1,000 gallons for irrigation.

The job, then, is to knock the cost of desalted water down to an acceptable level.

Secretary of the Interior Fred A. Seaton, in his latest report to Congress, announced significant progress and commented:

"If research and pilot-plant work now started is successful, it appears reasonably certain that costs of large-scale distillation of saline water will be reduced to 50 cents or less per thousand gallons in the near future."

How near is the near future? OSW officials don't say.

Testifying before a House Interior Subcommittee, OSW Director David S. Jenkins called the program the most difficult assignment in physical chemistry and engineering economics ever undertaken by the Federal Government.

Jenkins talks of the 5-year-old program as being still in its infancy, but recently he hazarded this forecast:

"If present research is successful, fresh water from the sea should be available within 5 to 15 years at prices which many industries and some municipalities can pay."

Right now the Federal agency is banking heavily on a series of pilot-plant tests scheduled to begin late this fall or early next year, under contract with the Office of Saline Water.

Currently regarded as the best bets so far among six-hundred-odd proposals submitted since 1952 are the following:

1. Hickman rotary process. Developed by London-born Dr. Kenneth C. D. Hickman, of Rochester, N. Y., former Eastman Kodak research director, the pilot plant is designed to produce 25,000 gallons per day of fresh water from the ocean through vapor compression distillation.

Using low heat, it is less subject to scale formation, which has been the nemesis of high-temperature methods.

The Hickman plant, already built, is now being created for shipment from Cambridge, Mass., to its seaside site at Harbor Island, N. C. Tests running at least a year are expected to start in November.

2. Badger multiple-effect distillation process. Invented by W. L. Badger, of Ann Arbor, Mich., former University of Michigan professor. The pilot plant is now being erected at Harbor Island and may begin operating in October. If successful, it would serve as the model for a mass-production plant costing over $6 million with a rated capacity of 17 million gallons per day.

The big if in the Badger process, according to OSW officials, is whether it can eliminate scale deposits which could clog the apparatus.

Badger told the House Interior Committee his multicycle process is "much cheaper than anything that has ever been talked about." He said he expects to desalt sea water for "somewhere between 30 and 40 cents per thousand gallons—provided I can lick the scale problem." And he expects to solve that within a year.

3. Plastic solar distillation. A new, tough plastic developed by E. I. du Pont de Nemours Co. may provide a relatively inexpensive method of open-air distillation, using the sun's heat to vaporize salt water in shallow plastic-covered basins.

Much cheaper than glass, the Du Pont plastic reputedly will stand at least 10 years of exposure in the hot sun. OSW Director Jenkins calls it an important step forward, but Du Pont officials say they still have a long way to go to make their method cheap enough.

4. Lof Process. Developed by Dr. George O. G. Lof, Denver engineer, this new design in solar distillation uses a still in which the ground acts as a storage tank for the sun's heat and continues to evaporate water when the sun isn't shining. In most solar stills, evaporation tapers off when the sun goes down.

Lof estimates his method will produce one-fifth gallon of fresh water per square foot daily at 50 cents per 1,000 gallons.

Pilot-plant tests of both the Lof system and Du Pont's plastic had been scheduled to held on a 6-acre site at Ocean Beach, near San Diego, in the next few months.

However, Congress slashed OSW's meager funds so sharply that the agency is now counting pennies to see whether it has enough money to go ahead with the solar tests.

OSW experts, while reluctant to criticize any feasible process, emphasize that solar distillation systems have the inevitable drawback of requiring long hours of hot sunshine and large areas to contain the flat trays of glass or plastic-covered water.

As an example, it would take an estimated 8,000 acres for a simple solar evaporation system to match the projected 17 million gallons per day output of the Badger process.

Many other systems—involving desalting by freezing, ion exchange, solvents, nuclear energy, osmosis, etc.—are still in the experimental stage but are not discounted by OSW officials.

The tiny Federal agency, with its 11-man staff, now has 21 research and development contracts and has enlisted the cooperation of 400 scientists and engineers. It has spent $2 million in the past 5 years.

With the handicaps of a skeleton staff and trimmed-down budget—Congress knocked $434,000 off its request for $1,159,000 for fiscal 1958—the agency has encountered rough sailing on Capitol Hill.

Senator ANDERSON. I want to say to the Senator from California that I appreciate the very kind way in which he referred to the chairman of this subcommittee and I say to him that I have had a deep interest in this saline-water program because of its possible effect on other programs that are now matters of controversy.

I need not remind him that there is some slight controversy between California and Arizona over water. That spreads to a division between the upper basin States and the lower basin States in the Colorado River system.

The controversy prompted me to try to check as to what we might do to get a peaceful solution. One recommended solution was that we buy back from Mexico the water granted to Mexico under the treaty we signed with them. The cost of that would not be much more than the cost eventually, I think, of erecting very large plants along the coast that would give the city of Los Angeles and the surrounding country far more water than it can ever hope to get out of the Colorado River.

For that reason it seemed to be sensible that we try to explore this alternative since, if water supplies continue to diminish in the rivers, a continuation of the status quo would mean endless friction between those States.

I went so far as to try to find whether or not the scientists who had been engaged in the development of atomic energy and the development of the first hydrogen bomb had any ideas as to what might be done.

I found not only that they had ideas, but they had convictions that by the expenditure of what looks like a staggering sum, $600 million to $800 million, a plant could be built which could completely solve the water problems of Southern California.

Of course, no one would start to build a plant of that magnitude without some tests. It just happens that within the last week or 10 days the chairman of this subcommittee had a chance to talk to Steve Bechtel of a very well known engineering firm in California.

As to the results of the first plants that had been built for development of atomic power, I learned from him something of the savings that could arise from the use of higher temperatures. The water program is one to which I was directed because of a document which came across my desk from the Atomic Energy Commission dealing with the desirability of obtaining temperatures in the neighborhood of 1,400°.

Then simultaneously finding a desalting process that would need to lift temperatures in the neighborhood of 1,400°. Here we were at an absolute exchange point where the two programs could work together.

Not being a scientist I did not know whether they had a relationship, but some scientists thought they had a great relationship. Be-

cause I think the only ceiling there seems to be on the growth of the State of California is the water ceiling, it did occur to me that this is one problem in which many of us should find a great deal of common interest.

I am happy that the Senator from California is here this morning even though he and I have had a couple of long days with the San Luis project just recently.

Senator KUCHEL. My people have lived in California, as I think I have told you, for considerably over a hundred years. I can remember my late father telling me that the area in which I was born and raised in southern California had artesian wells all over that vast area of land.

As a small boy I can remember my family taking me within 10 miles of Anaheim and seeing artesian wells gushing apparently the purest type of water into the air.

Those are all long since gone, and what a turnabout has taken place when you and I listened on Monday and Tuesday to the perfectly prodigious cost to which farmers are placed in being required to dig deep into the ground considerably over 100 and sometimes over 200 feet to obtain brackish water in order to sustain their own economy.

That is what has happened to our land of abundance in the last century.

Meanwhile, the people continue to come out there.

Senator CASE. Mr. Chairman, in going through my files to look for the parts per million which I have found and will give to the reporter, I have come across a letter which I am moved to bring to your attention because I know your interest on this is partly augmented by your realization of the importance of fresh water supplies in case of atomic developments that would spoil some of the water.

But I received a letter from an electrical engineer in South Dakota by the name of Earl Smicter, back in 1954, in which he said:

> In the next 50 years the atomic engineer is not the man who will be lauded, but the engineer who will desalt the ocean water using the chemicals and minerals recovered to practically pay for the desalting cost and the lifegiving pure water will be used for city and irrigation use.

He may be a bit optimistic on that point, or maybe a little bit prejudiced, but I think the possibility of recovering minerals sufficient to pay for the cost may not be realized in the immediate future, but it is worthwhile knowing that the Dow Chemical Co. supplied a great deal of our magnesium during the war with the Dow process for recovering magnesium from ocean water.

Senator ANDERSON. I do not know what the final cost will be and I am not really worried. I only know that as we develop atomic power, we must find ways of controlling extremely high temperatures.

I have had occasion to take a look at a small device which heated to 2,500° which is a little hotter than I thought I would ever look at.

Now, if the breaking point where it seems extremely easy to desalt sea water is 1,400° and we are already beyond it, we are beyond it in laboratories, we may not be too far away from suggesting some combinations.

It was my thought that if that point is ever reached in our atomic energy research, we might be ready, by knowing a lot of other things, to desalt and improve water, if in the meantime we are building these

plants and learning some of the things that you have to learn the hard way as you experiment with them.

When the Senator from South Dakota started to say some things and then the Senator from California took up, it reminded me that not too long ago I was speaking in California, trying to interest the city of Los Angeles still more in the program than it had been interested in the past, and I reminded them of the water involved in a slice of bread. Growing the grain uses 37½ gallons of water. We have reached the point where we now use 1,100-gallons of water a day for each man, woman, and child in our population or 200 million gallons a day over the Nation. The experts all predict, by 1975, that we will have at least 220 million people.

If you throw that population increase against a very fast rising curve of water consumption, you will have a water problem that puts a ceiling on a great many of the cities and a great many of the metropolitan areas of the United States.

I do not want to burden this record with reading a lot of statistics, but the problem that southern California will face as its population grows and the needs of the individual people grow, is staggering.

I saw a photograph made from the air of a certain section of California 10 years ago. Then I say a second photograph made 25 years ago and a photograph made last fall.

Now, the object of the photographs was to show that two things: A rising tide of population and an increasing interest in swimming pools. At last calculation, swimming pools used a small amount of water. Here was an area just outside of Los Angeles with, it seemed, hundreds of homes, and you could hardly spot a house without spotting a swimming pool, either adjoining it or between two houses right in the same neighborhood.

Now, nobody wants to change that style of American living. I think I have more pleasure out of my heated swimming pool than out of anything that I own in New Mexico, and I do not want anybody to have to stop having swimming pools nor do I want to have them stop having lawns and using air-conditioning systems and all the other things that greatly increase the joy of living.

That is why I have felt that we should start looking ahead and calculating the population we might have by the year 1975 and then by the year 2,000, then apply against that the curve of increasing water consumption and find that there is hardly an area in the United States that is not water deficient to a degree.

The Senator from South Dakota knows this from his own area, of very small population comparatively.

When I went to the House of Representatives in 1941 I was on the committee that reapportioned the membership of the House, or considered the formula for reapportionment. I think California had about 21 Members of the House at that time. I think it has something like 30 now, and will have probably 37 or 38 at the time of the next census.

Senator KUCHEL. Maybe 40.

Senator ANDERSON. Do not discourage me. We are outnumbered badly enough now.

But that is an indication of the tremendous growth in population and you cannot just take that population growth. You have to take the consumption increase.

Testimony was given here on the San Luis project and showed areas that once had artesian flow and now had wells. Those wells are right down to the salt water. They have no other place to go except to try to develop some new water supplies.

They are not far from the sea coast. The one real essential to huge atomic development of potable water is the necessity of being at the sea coast with enormous populations. It is a subject which I am sure is going to be very fascinating to the people of that State in the coming years.

We could easily get back all the money we have spent in atomic energy on isotopes. We are almost at that point. But we could get our money back many times over if we solve this water problem.

The first witness will be the Assistant Secretary of the Interior, Hon. Fred Aandahl. The Department's report has come up finally on these two bills.

Do you intend to refer to it, or shall I put it in the record at this point?

Mr. AANDAHL. I have a brief statement that I will read.

Senator ANDERSON. We are happy to have a statement. I just want to say, Mr. Secretary, that I take a rather dim view of the unfavorable recommendation you made on both S. 135 and S. 3370, but I hope you stay here long enough and hear the testimony on these and then go back to the Department and seek to get a little better report from the Department, if you can do so.

Mr. AANDAHL. I think probably, Mr. Chairman, that our thinking is not too far apart.

Senator ANDERSON. I know it is not. I want to say to you that I was deeply sorry that the Secretary of the Interior could not have been here himself, because I am persuaded that as we move further in this field the Secretary of the Interior and Assistants, such as Secretary Aandahl, will be very helpful in the development of this work because Secretary Seaton, I know, for a long time, has been very much interested in this possibility.

I know the same observation applies to you, Mr. Aandahl, and I am happy to have you as a witness here this morning.

STATEMENT OF FRED G. AANDAHL, ASSISTANT SECRETARY OF THE INTERIOR, ACCOMPANIED BY DAVID S. JENKINS, DIRECTOR, AND JOSEPH J. STROBEL, CHEMICAL ENGINEER, OFFICE OF SALINE WATER

Mr. AANDAHL. I am glad to be here, Mr. Chairman. We from the Department of the Interior are indeed pleased to appear before your committee today to review the work of the saline water conversion program and to try to outline a course that should be followed in the future.

On the question of the need for this program, it is probably sufficient to say that all studies of our future needs for water agree that there will be ever increasing demands on our sources of supply. While the total amount of usable water in the United States is sufficient for a good many years, there are many areas where the supply is currently insufficient and great effort is being made to bring water to these places. Some of them are near the sea or near sources of brackish water.

A method of converting such waters to usable fresh water at a reasonable price is the challenge that confronts the work of the saline water conversion program. Methods of converting sea water to fresh water have been known and used for a long time. Without aid from the activities of the Federal saline water conversion program that was established in 1952 and which we are considering today, methods have been developed and have been put into limited use on a fairly large-scale basis which will convert sea water at a price of about $2 a thousand gallons.

The objective of the saline water conversion program has been to develop means of lowering that cost either by improvements on the methods that are in use or by the discovery, development, or expansion of other processes. A brief outline of what has been done under this Federal program will serve as a guideline in determining what needs to be done in the future.

Since the establishment of the program in 1952, hundreds of proposals or ideas for research on a wide variety of conversion processes have been considered and evaluated. From those evaluations contract research has been carried out on some 30 potential processes or methods. That work has resulted now in concentration of effort on the following general areas: Distillation, such as vapor-compression, multieffect and solar; membrane processes of several types; freezing; and a group of other chemical and physical possibilities.

Small pilot plant development has been carried on on a membrane system of about 25,000 gallons per day capacity operating on brackish waters. Another is being conducted on a sea water rotary vapor compression distillation method, also of 25,000 gallons per day design. A third pilot activity is underway on the vertical multieffect distillation process operating on sea water. These last two are currently in operation at Harbor Island, N. C. A group of five small pilot solar stills are in the process of being placed under contract for construction and operation. Other processes are now or soon will be ready for initial pilot plant testing. These include a freeze-evaporation system, the osmotic membrane method, and osmionic process using selective membranes. Several methods, such as the flash evaporation low-temperature difference system, and nuclear energy combinations do not lend themselves to small pilot plant construction. Rather, engineering designs, plans, and analyses are needed to propose larger installations. However, particular phases of those types of processes may need investigation by medium sized pilot plant facilities.

The next necessary step as I visualize it is to extend the pilot plant phases of the program. In the next several years, designs for and probably beginning of construction of those next steps in pilot plant testing can be made on: 3 or possibly 4 kinds of distillation processes; 3 types of membrane processes; 1 freeze-evaporation process; possibly 1 solvent extraction process; and designs of a nuclear heat-distillation combination.

Such a program can be carried out in either of two ways. One approach would call for a very rapid rate of activity with all processes undergoing pilot plant developments concurrently. The other approach would entail pilot plant activities on a few of the most promising processes at a time, on which problems need to be solved, either in the small or medium-sized pilot plant stage.

Either method can be carried out efficiently and effectively if funds, facilities, and personnel are available. The degree of actual urgency in developing one or more or all of the processes for one or all types of uses would depend entirely upon the specific and the overall water requirements and needs of the country.

I am very glad to be able to add that the information that I have and the opinion of the people who have been working in connection with the two processes that are currently under pilot plant testing at Harbor Island, N. C., indicate that these methods show strong possibilities of being able to reduce the earlier mentioned cost of $2 per thousand gallons to less than half that amount with possible further reduction in the future.

We in the executive branch during the last year or two have been trying to push the pilot plant testing work forward at a somewhat faster pace. For fiscal 1958 we asked the Congress for an appropriation of $1,159,000 for our overall program. The appropriation that we actually received was reduced to $725,000. If all the requested funds had been available during the current year, we had expected to have in operation by this time a solar distillation pilot plant appreciably larger than the ones that we now hope to have in operation soon. We also would have expected to have small pilot plants started on the freezing, osmotic, and osmionic processes. Additional engineering studies on pilot plants required for nuclear energy combinations with conversion would have been undertaken. Also, some thought had been given to procuring a minimum experimental test facility at a seashore location.

The Department is in agreement and in sympathy with the principle that the saline water program should be expanded to assure acceleration of the activity and early and orderly advancement in the determination of a means of converting sea water at a price of one-fourth of the present $2 cost, or even less than that if possible. As I see the program we need to direct our attention to four steps to accomplish this purpose:

1. Continue the work in basic research.
2. Put more processes under initial pilot plant testing. I say initial testing instead of small- or medium-sized testing because by their nature some processes can be tested first by small units and others require fairly large equipment to do any testing at all.
3. Expand and continue the pilot testing of some of the processes that are already in or through their initial pilot testing.
4. Have available suitable test facilities at the sea.

Review of the authorizing legislation presently in effect indicates that its terms are very broad and authorizes the Secretary to conduct the necessary steps, as I have outlined them. It may be necessary, however, as the program progresses to reconsider its fiscal and time limitations.

I might say, Mr. Chairman, that the Secretary was very sorry that he could not be here. It was not until just a day or so ago that I was advised that I would have the responsibility of representing the Department at this hearing.

I would like to say at this point, Mr. Chairman, that the Department of the Interior through the Office of Territories is planning a production plant at the Virgin Islands. That is entirely a separate

and independent consideration from what we say here about the research and experimental work of the Office of Saline Water.

There is no conflict at all in those two approaches.

I also want to add that I have with me today from the Department representatives of the several bureaus and agencies which you have requested be present, and with me at the table is Mr. Jenkins, the Director of the Office of Saline Water.

We will be glad to discuss this matter with you and attempt to respond to questions as the committee may see fit.

Secretary ANDERSON. I understand that Mr. Jenkins has a prepared statement. We will receive it at this time and print it at this point in the record.

(The statement referred to is as follows:)

STATEMENT OF DAVID S. JENKINS, DIRECTOR, OFFICE OF SALINE WATER

Thank you, Senator Anderson. It is a pleasure to meet with you and the committee again.

May I first take the liberty of thanking you, Senator Anderson and Senator Case, for your very kind statements to the Senate of the United States concerning the work of the little Office of Saline Water. Everyone of the 13 employees of the Office of Saline Water was heartened on reading your kind statements and I give you both my assurance that we shall do our very best to justify your faith in us.

It would be very difficult to summarize all of the activities of the saline-water program in a few minutes. Copies of our annual reports for 1957 have been distributed to the committee members. That report describes the process developments for the past 5 years, including the methods of operation, the organization and administration of the program, the methods of receiving, evaluating, and initiating research and development projects, the coordination of the activities with others working in this field, the stimulation of private work, and contains an extensive table in which we have attempted to list all known work in this field wherever it may be.

The replies which were sent to the committee in response to your letter of February 10, can be summarized about as follows:

The methods of evaluating research and development proposals follows closely the procedures of the National Science Foundation; panels of outside private consultants are relied upon very largely to determine the merits of new and continuing research work.

As to targets, at the beginning of the program, one guide for the cost to be sought initially was chosen as the maximum prices known to have been paid for undistributed, untreated raw water for municipal purposes, This was about 30 cents a thousand gallons, or $100 an acre-foot. It was also recognized that the prices paid in some instances for industrial water were considerably higher than this and ranged up to $2 or more per thousand gallons, or about $700 per acre-foot. Between those 2 prices—$700 down to $100 an acre-foot—there existed then a range of prices from $2 down to 30 cents a thousand gallons in which an increasing number of industrial uses for converted water will take place as process costs are reduced. When the costs approach 30 cents, some municipal uses should make their appearance.

Now this principle of comparing costs for converted water with actual costs of fresh water is in principle, I believe, a sound way to go about our program for reducing costs. However, I am not unmindful of the fact that as we progress, new improvements of all kinds are adopted and quite often the alternative facility will have costs greater than whatever it replaces. I was greatly impressed by the passage in the letter which I received recently from the Head of the Marketing Research of one of the country's large industrial organizations which he has given me his approval in which he stated as follows:

"A quick glance at the history of the major technological advances in consumer goods shows that virtually none have been more economical than the thing they displaced. In every case, automobile, electricity, radio, television, aircraft, they provided consumer services that did not exist before. We would have been extremely foolish to have denied acceptance to them because theoretical economic calculations showed them to be more expensive than existing albeit inadequate, services."

As stated in the material sent to the committee, the processes which offer promises of reduced costs fall into four general groups: Distillation, including solar distillation, in which the cost in 1952 ranged from $2 to $5 per thousand gallons and which now is estimated for designed or projected installations at from $1 to $3 with anticipated costs in the future of less than 50 cents. For the second group of membrane processes which were not yet developed in 1952, the cost at the present time for treating brackish waters of 5,000 parts per million is estimated at around 80 cents in this country and it is anticipated that in the future that cost should be reduced to less than 25 cents. Separation by freezing, the third general group, was not in existence in 1952, but is now a small operating model today. However, it is anticipated that with further successful research and pilot-plant work, the cost should be less than 50 cents per thousand gallons. The group of other processes, including extraction of fresh water by the use of solvents, likewise is anticipated to have costs in the future of 50 to 25 cents for sea or brackish waters, respectively.

Several of the processes under development by the Department are to be discussed by representatives of the organizations which are or have been developing them under contract with the Department. The Badger long tube vertical distillation cycle will be described by Prof. W. L. Badger. It is showing excellent promise. The Hickman vapor compression system and the solar distillation work will be described by Mr. Bertrand Landry, of the Battelle Memorial Institute, which is now carrying on the further pilot-plant development in those fields for the Department. The promising work in separation by freezing is being carried out at Carrier Corp., which will be described by Dr. Dewey Sandell. The work that has been carried out for the Office of Saline Water by the Fluor Corp. on nuclear-energy combinations will be described by Dr. William R. Hainsworth, vice president of that well-known engineering and scientific organization of Whittier, Calif. The work on low-temperature flash distillation which offers real promise for locations where a supply of warm water is available will be described by Mr. William Gardner of the Griscom-Russell Co., which has carried on contract work for the Department in that process. Therefore, I had not planned to go into detailed description of those processes at this time. However, there are three processes which are under development by the Department which show excellent promise, particularly for use on brackish waters and these I feel should be described briefly as follows:

Osmionic.—The osmionic process is an entirely new method which has been developed under sponsorship of the program. It is somewhat similar to electrodialysis except that it requires no outside electrical current and no electrodes. The driving force is obtained from the differences in concentration between a brine and the water to be demineralized. This feature makes the process very attractive in areas where the electrical power is not available, but where supplies of concentrated brines can be obtained easily—possibly by open pond evaporation and concetnration of sea water. The work was developed by Dr. George Murphy at New York State University and when it reached the engineering phase was transferred to the Southern Research Institute at Birmingham, Ala., where it has been advanced to a small bench pilot model. This has demonstrated the technical feasibility of the process. A pilot plant is now needed. Costs cannot be estimated closely but appear competitive with other processes under development.

Reverse osmosis.—Osmosis involves the passage of water through a membrane from a dilute solution to a more concentrated one or from the fresh water side into the salt water. If enough pressure is applied to the salt solution, the osmotic flow can be reversed and pure water from the salt solution will be forced through the membranes into the more dilute solution. Hence the term reverse osmosis.

This process has been operated successfully in the laboratory, and at the University of Florida a laboratory unit capable of producing 8 gallons of fresh water per day has been constructed. This process utilizes the ion restraining or osmotic-type membranes and presently available membranes are capable of taking out approximately 97 percent of the salts from sea water in 1 pass. The durability and the flow rate of the films, however, must be increased before the process can become practicable.

Solvent extraction.—This process which has been developed at Texas Agriculture and Mechanical Research Foundation utilizes a liquid which will absorb large quantities of water but at the same time the compound must be practically insoluble in water. The solvent extracts the fresh water from the salt water and

then releases the fresh water when the system undergoes a slight change in temperature.

In addition, I should like to mention briefly the processes now in commercial use. They consist of large-scale multiple effect distillation of two types; conventional compression distillation; and electrodialysis. Multiple effect distillation can be built on relatively large sizes up to 20 or 30 million gallons a day or more. Westinghouse Co. has recently constructed a plant at Kuwait, consisting of 4 units each about 600,000 gallons a day. Others are in use for special purposes. The cost of water is about $2 or more a thousand gallons. Improvements and combinations with power-generating plants may lower the cost of water considerably below $2. Existing large vapor compression plants are of about 50,000-gallon capacity and the cost of the water is computed at $2 to $3 per 1,000 gallons or more. A number of competent American and other industrial firms are capable of designing and producing these various distillation plants.

Electrodialysis is adaptable largely to brackish waters and the cost of the demineralized water depends on the salinity of the original water. For waters such as are found in parts of the West containing 2,000 parts of salt in a mililon parts of water, the cost of demineralizing down to good drinking water salinity has been estimated by one American manufacturer from pilot-plant tests run on its equipment by the Department as $1.10 per 1,000 gallons for a plant of 25,000 gallons daily capacity, and $0.60 per 1,000 gallons for a large plant of 1,500,000 gallons. Other electrodialysis equipment developed abroad is reported as at least meeting these costs.

Senator ANDERSON. Do you have some slides, Mr. Secretary?

Mr. AANDAHL. We have some slides from the Office of Saline Water that may be used in answering questions. We don't have any general projection that we want to present to the committee.

But if a question should come up about certain phases of our work, we have some slides that will be helpful in explaining what is being done.

Senator ANDERSON. As I understand your statement, you prefer to proceed under the available authorizing legislation rather than any new legislation which would authorize a full-scale demonstration plant?

Mr. AANDAHL. I feel that there is still a great deal of work that needs to be done on the basis of pilot-plant operation. That might involve some fairly sizable pilot-plant operation.

The next step in one of the processes that is in initial pilot-plant testing at Harbor Island would probably require a million-dollar pilot plant with a capability somewhere near a million gallons per day.

That would be quite a sizable pilot-plant authorization.

It is our understanding that the present legislation authorizes us to conduct that kind of work. I feel that those steps are very essential before we would consider what might be classified as a demonstration plant.

Senator ANDERSON. Would the demonstration of this million-dollar plant be at all improved if you tried a little larger plant? Does the process you are going to test not offer its greatest possibilities when it is running at much greater capacity than the one now contemplated?

Mr. AANDAHL. I think what you say is generally correct, but I think a plant of the size I have suggested there would be large enough to give us all of the information that we need, probably make a number of suggestions for improvement, and I think it would be desirable to have that before we went into the larger operation.

Senator ANDERSON. How long would it take to develop that?

Mr. AANDAHL. I believe I would have to ask some of our people to respond to that.

Do you have a suggestion, Mr. Jenkins?

Senator ANDERSON. You have this plant that is now operating at North Carolina.

Mr. JENKINS. Yes, sir.

Senator ANDERSON. How large is it?

Mr. JENKINS. The plant that is in North Carolina now is a test facility only, in which one evaporator or just a part of an evaporator is being used for solving what we call the scale problem, the prevention of scale in this equipment.

I do not believe we have run capacities on that little facility which we have.

Senator ANDERSON. Relatively how much larger would the plant be that you are talking about than the plant you now have? These scientists talking in atomic energy are always talking about some orders of magnitude. Can you not give us some order of magnitude?

Mr. JENKINS. Eight to twenty times as large in physical size.

The 1-million-gallon plant would have all of 8 or 10 or 12 stages. This is just one stage and only part of that stage.

It is for an entirely different purpose, merely to work out what we must have before we go into any kind of a multieffect installation for further work.

Now, in answer to your question as to whether we could go into a much larger plant, that could be done, but there are problems that we know will arise which we can solve, we believe, in what would be the next logical size, something between a half million gallon and a million and a half gallon, perhaps.

I should say that Dr. Badger, who has been working with this system for many years, has used it in the salt industry and chemical industry, is here. He is to appear before this committee and describe this process and the work at Harbor Island in considerable detail.

Senator ANDERSON. I am sure I sound as if my thinking is all running in one direction, but recently we had some publications as to the development of thermonuclear power and it was revealed that the people at one of the laboratories in this country had built a small demonstrating test unit to see if they could make neutrons.

The British took the same program, took a pretty substantial jump, and built a substantially larger machine. It looked as if they had far greater technical skill than we had, but it was only the fact that we were so careful that we did not build anything too large to demonstrate anything too much, that the British got ahead of us.

Is there a possibility that we are proceeding with a little too great caution in this field? Are most of these things pretty well known that you are talking about? Have you not dealt with the scale problem pretty well?

Mr. JENKINS. No, sir; not in this particular problem.

Senator ANDERSON. In what respect does it baffle you still?

Mr. JENKINS. In this particular cycle the economy of the cycle depends in a very large measure upon the use of ferrous metals rather than copper nickel metals.

Scale can be dealt with if corrosion resistant metals are used with the adjustment of what we call pH, by the addition of acid.

Dr. Badger believes that processes used by many in the salt industry in which acid need not be fed, can be used on sea water.

We do not know this yet. We will know when we finish at Harbor Island.

We do now know that the equipment can be kept scale free with the use of acid. If so, it will cost somewhat more than we have computed because of the more expensive metal.

Senator ANDERSON. When do you hope to get this other answer?

Mr. JENKINS. In January I reported to the Appropriations Committee that we felt we would need 6 months or more, maybe a year of testing, and that our appropriations requested for next year would not include the engineering work.

In the past 2 months, however, the results have been coming in which are quite favorable and I talked with Professor Badger yesterday and he feels that engineering studies could begin at any time.

We will not know all of the answers for a few months yet, but engineering of a plant could begin now.

Senator ANDERSON. The Senate joint resolution provides that the decision shall be made 6 months after the approval of the act. So if you made such fine progress in the last few months, and I agree that you have made very encouraging progress, by which you almost know you can take care of the problem without difficulty, you might be able to take a larger step than you contemplated when you said 6 months.

Mr. JENKINS. I believe, Senator Anderson, that we would encounter the same problems that would have to be solved in a plant of 10 or 20 million gallons that we would encounter in a 1-million-gallon plant and it would be a lot cheaper to solve them in a 1-million-gallon plant.

Seantor ANDERSON. Would you learn anything extra out of a larger plant?

Mr. JENKINS. Yes, sir.

Senator ANDERSON. That is what I was trying to get to. You would learn a lot of things?

Mr. JENKINS. Yes, sir; but there are things which would cost a great deal of money to learn in a large plant that you can solve in a smaller plant of say 1 million gallons.

Senator ANDERSON. Precisely, but here is a State of California talking about its general water plan and unless it can take care of the situation, unless it can do something about sea water, the people out there are going to be asked to spend $11 billion.

The interest on $11 billion, I assume, runs into quite a little money.

I do not want to stop to think about it, but I know it is quite a bit. Somebody has to pay the interest on that. Whereas, if we could make some headway with desalting sea water, with the great population centers all up and down the coast of California, they might not have to spend all that $11 billion.

Would that not be some advantage even if it did cost a little extra money?

Mr. JENKINS. Senator Anderson, I believe that is a policy question. I am trying to answer the technical questions. I should say this: That the work which has been done at Harbor Island and the plan which we have, has been worked out with the help of some of the country's most outstanding engineers and scientists who have reviewed this work and have recommended this set of steps.

Senator ANDERSON. Could it be that those outstanding scientists who have recommended it, and they are undoubtedly fine people, have not made a population study, a study of increased water consumption which shows how quickly this problem is going to be on us in California?

I grant that they have been cautious and probably done it in the proper scientific way, but some people in the last few months have been taking some jumps, as was demonstrated by sputnik.

I wonder if maybe we might not take a jump or two in this field.

Mr. JENKINS. Senator Anderson, I have always considered that to be a matter for the judgment of the Congress in regard to the urgency.

Senator ANDERSON. If we pass a resolution urging the building of a plant that will be an expression of policy; will it not?

Mr. JENKINS. Yes, sir, and we will carry out happily and as best we can anything that the Congress wants us to do.

Senator ANDERSON. And if Senator Case wants to see a plant built to test brackish water, that was a little bit more than just a pilot plant, it would be possible to build a fairly sizable one, would it not, without too much of a jump, with the present engineering knowledge of the things we are now learning?

How much would be involved in the construction of the type of plant that Senator Case has in mind that you have not yet experimented with?

Mr. JENKINS. Processes designed especially for treatment of brackish water are confined to just one fully developed process at the present time.

Senator ANDERSON. Which is that?

Mr. JENKINS. The ionic membrane process. In this country, Ionics, Inc., is the only organization that has built and is selling such equipment.

Senator ANDERSON. Would you like to broaden the market a little bit?

Mr. JENKINS. Definitely. We took that equipment to the field and ran pilot plant tests; we have a very through report on it showing the cost of the water which comes out to be, for the water treated in Miller, S. Dak., in the neighborhood of 60 cents a thousand gallons for treating that brackish water, as estimated by the company, if a large plant were built.

We believe that much further work is needed and that those costs can be reduced to much less than that with further work.

Senator ANDERSON. That is fine; that is encouraging, and I am glad to have it.

Senator CASE. Of course, that cost would be attractive to many municipalities if you could demonstrate that you could build a plant which would serve the communities of under 10,000 population, if you could serve a community of 1,000 or 10,000 population, and give them salt-free water for 60 cents a thousand gallons, that would be a very definitely attractive proposition.

Mr. AANDAHL. I just was wondering if it would not be well to have in the record an estimate of the size of plant that would be needed for that purpose.

Senator ANDERSON. Yes.

What size plant would that be?

Mr. JENKINS. I believe that the per capita daily consumption in a town such as Miller runs in the neighborhood of about 100 gallons. I think Miller has about 2,500 people. That would mean a quarter of a million gallons per day if my arithmetic is right.

Senator ANDERSON. One hundred gallons per day per person. They are way below the national average, then.

Senator CASE. Of course, there is no industrial use in Miller.

Senator ANDERSON. I realize that. I would like to ask a couple of questions, if I may.

Mr. Secretary, you referred to a plant in the Virgin Islands.

Mr. AANDAHL. Yes.

Senator CASE. What is that project?

Mr. AANDAHL. That is merely a project to supply badly needed water in the island. The plant would be installed there, but would be one of the tested commercial plants that is in use at the present time.

Senator CASE. When you say a tested commercial plant——

Mr. AANDAHL. It would not necessarily be a product of the Office of Saline Water. The Office of Saline Water will work very closely with the Office of Territories to help them to determine the most economical type of plant to install down there, but the chances are that it would be a plant similar to one of the plants that is used in a number of places.

There are several types of plants that have been built for commercial production of water.

Senator CASE. You have not yet determined what type of plant will be used?

Mr. AANDAHL. No; I am not sure. The people from the Office of Territories are here and they will be able to report to you what they have in mind.

Senator CASE. And also tell us something of its size?

Mr. AANDAHL. Yes.

Senator CASE. In the report of the Secretary, I note that you included the tables showing the amount of the budget estimates and the amount of money that Congress had appropriated. Just making a quick rundown of that, it would appear that there has been a total appropriated of about $3 million and with the request for 1959, based on the House appropriation, a total of perhaps about $3½ million which has been appropriated for the Office of Saline Water or will have been at the end of 1959.

Mr. AANDAHL. That is correct.

Senator CASE. Out of an authorization which you have in existing legislation of $10 million?

Mr. AANDAHL. Yes.

Senator CASE. What is your definition of a demonstration plant as compared with a pilot plant and as compared with a laboratory test?

Mr. AANDAHL. I can give you only a layman's appraisal of that, but my understanding of a demonstration plant would be one that embodied a sizable degree of production, it was intended to show the public what actually could be accomplished in the converting of seawater to fresh water, while to me a pilot plant, irrespective of size, carries a connotation of one that is built for further research and is experimental for developmental purposes.

I think the type of thing we are trying to do in the saline water program, we want to stick with the pilot plant concept just a little bit longer.

Senator ANDERSON. Now, I am interested in this because, as you have probably already guessed, I am a little impatient, I hope not too impatient.

Tell us about this plant in Miller, S. Dak. When was it put in there?

Mr. AANDAHL. The plant that was used at Miller was a mobile unit.

Senator ANDERSON. It was a trailer?

Mr. AANDAHL. It was used in Arizona for 6 or 7 months and then later in South Dakota and is presently in the Bureau of Reclamation laboratories in Denver with some experimental work continuing on the membranes.

Senator ANDERSON. Was it at Miller longer than 6 weeks, or so?

Mr. AANDAHL. I think we had better have Mr. Jenkins give you that.

Senator ANDERSON. We had a figure a little while ago based on what it cost at Miller. I am trying to find out what experience you had in Miller.

Mr. JENKINS. It was in Miller about 3 months. It was earlier tested in Arizona about 6 months.

Senator ANDERSON. Are you sure they ran it longer than 6 weeks at Miller?

Mr. STROBEL. The test was 3 months' duration. It was intermittent operation, but it was 3 months.

Senator ANDERSON. You would not be too shocked if I said 6 weeks of actual running?

Mr. STROBEL. No.

Senator ANDERSON. When you got it out of there, you moved it to Denver? How much have you run it at Denver in the last 3 years, 1,000 hours maybe?

Mr. JENKINS. As I recall, we received a report which stated that about fourteen hundred hours—I might want to correct that for the record—has been placed on membranes.

Senator ANDERSON. I was not too far wrong, was I?

Mr. JENKINS. No.

Senator ANDERSON. So your experience was based on limited operation of a limited plant that is carried around in a trailer.

Is that, Mr. Secretary, your idea of a good pilot plant experiment in the handling of brackish water?

Mr. AANDAHL. I would say that that is a good initial pilot plant operation. If that initial operation has the proper elements of encouragement in what was accomplished it should move into a larger pilot operation and probably take the form of stationary construction.

Senator ANDERSON. You say if it had the proper elements of encouragement. What have you learned, Mr. Jenkins, in these 4 years by use of this ionic membrane process, from this trailer?

Mr. JENKINS. We have learned that the particular equipment which is built in this country is designed for a particular purpose and that is with rather high labor costs and equipment costs.

The membranes, for example, we are finding very durable, but they are very expensive.

Senator ANDERSON. Have you bought new equipment for it in the last couple of years?

Mr. JENKINS. No, sir; I don't think we have had to replace the membranes that were placed in the equipment in Denver.

Senator ANDERSON. Is this type of equipment being sold in other parts of the world?

Mr. JENKINS. Yes, sir.

Senator ANDERSON. Are they getting little advanced models over what you have been using?

Mr. JENKINS. I would assume that they are, not greatly advanced, so far as I can tell.

Senator ANDERSON. What I am curious about is, if you had this for 4 years and have not thought of a single thing, they have not, or you have not, thought of a single thing to improve it, how much of an experimental job has been going on and how much have you just been letting it sit day by day and hour by hour?

What have you really tried with it that is new? How much advanced thinking have you put into it? Can you tell us a little bit about that?

Mr. JENKINS. Yes, sir. I should say this, first, that the Office of Saline Water consists at the present time of 13 people, including clerical help. The total staff in the office, technical staff, is here with me today. It consists of five technical people besides myself. Two are well versed in membrane work. We have, by reason of the present law and the way we work, had to depend almost entirely upon private organizations such as Ionics, Inc., and others, to carry out the real developmental work.

Now, those organizations have been busy. One organization, the National Aluminate Co., has been busy developing greatly improved membranes.

I believe some of their representatives are here today.

Senator ANDERSON. Greatly improved membranes?

Mr. JENKINS. Yes, sir.

Senator ANDERSON. Have you tried them anywhere?

Mr. JENKINS. We have not.

Senator ANDERSON. How do you know, then, they are greatly improved?

Mr. JENKINS. We take their technical data as being correct.

Senator ANDERSON. Are you hostile to testing it?

Mr. JENKINS. No, we have a testing facility now being readied in the Bureau of Reclamation laboratories in Denver for testing many different kinds of membranes.

Senator ANDERSON. In the 4 years you have had this outfit why not try one of these improved ones. That might change your estimate that you gave Senator Case a moment ago.

Mr. JENKINS. We believe it will. We have a program in the Bureau of Reclamation for development not only for testing the membranes, that others are developing, but improving, developing improved equipment that the membranes are placed in.

Senator ANDERSON. At the present rate of speed when do you think that test will take place?

Mr. JENKINS. We are out of money this year. We are scheduled for the first thing next fiscal year.

Senator ANDERSON. That would start, you mean, this coming July?

Mr. JENKINS. Yes, sir.

Senator ANDERSON. So that is where the brackish water experiment stands?

Mr. JENKINS. Only on the Ionics, Inc. process. However, we have a number of development projects underway on other promising brackish water processes, and if you wish I can insert a list of them.

Senator ANDERSON. You may do so.

(The following information was subsequently submitted:)

BRACKISH WATER EXPERIMENTS

Not only has emphasis been placed upon processes which are principally suitable themselves for treatment of brackish water, but also on distillation and solar distillation, which can treat both brackish water and sea water. If distillation processes are used on brackish waters it will be possible to blend the pure distilled water with fairly large portions of the original brackish water thus reducing cost of the product water up to 50 percent in some cases. Following is the list of activities and expenditures this year on processes considered as particularly for treatment of brackish waters. The total for the year will be about $140,000. If say a third of the expenditure on distillation is also considered as applicable to the brackish water problem, the total for the year on brackish waters is about $300,000 or nearly half of the research and development effort for the year.

Activity	Process	Expenditure
Southern Research Institute	Osmionic	$24,831
University of Florida	Reverse osmosis	11,960
Texas A. and M	Solvent extraction	28,960
University of Oklahoma	Adsorptivity (extension)	5,000
Polytechnic Institute, Brooklyn	Membranes	6,960
Resources Research	Biological membranes	10,000
Evaluations on brackish water (estimate)		4,000
Bureau of Standards	Membrane development	15,000
Bureau of Reclamation	Electrodialysis	30,000
Total		136,711

Mr. JENKINS. The brackish water experiments have also been carried on abroad.

Senator ANDERSON. By your department?

Mr. JENKINS. No, sir; two organizations abroad have developed what has been reported as equipment at least equal in performance to that developed in this country.

Some of the reports indicate that it is superior.

Senator ANDERSON. Have you seen that equipment? Has any member of the staff seen it?

Mr. JENKINS. I saw one model of this equipment under development when it was very small, 2 or 3 years ago in Holland.

Senator ANDERSON. You have not seen it operating?

Mr. JENKINS. Yes, it was operating, that small model was operating.

Senator ANDERSON. I know, but the equipment that they now have which is of some size, is that not operating now abroad?

Mr. JENKINS. Yes, sir; they have a larger size now which is operating down on the English Channel.

Senator ANDERSON. Has any member of your staff seen it?

Mr. JENKINS. No, sir.

Senator ANDERSON. Are you really interested in seeing it?

Mr. JENKINS. Very much.

Senator ANDERSON. Would it be fair to ask you, then, why you have not seen it, or some member of your staff?

Mr. JENKINS. We have been more than occupied with the day-to-day work in this country.

Senator ANDERSON. If the whole experiment on brackish water was in lugging this trailer around a bit, that is not much day-to-day-work here; is it?

Mr. JENKINS. I believe I should say that I did meet with the people working in Europe, but there were some objections raised to that foreign travel.

Senator ANDERSON. By the Congress?

Mr. JENKINS. Yes, sir.

Senator ANDERSON. That is what we want to get to. We have been trying to get something done. We want to find out why that is. Was that an appropriations committee?

Mr. JENKINS. Yes.

Senator ANDERSON. We do not speak improperly of the other body in this place, but was it by any chance in the House of Representatives?

Mr. JENKINS. Yes, sir.

Senator ANDERSON. Was it in the Senate?

Mr. JENKINS. No, sir.

Senator ANDERSON. I would agree with you that if you wanted to go look at this and Congress would not let you, it certainly is not your fault.

The only thing I am trying to say, Mr. Jenkins, it is the feeling that not a cussed thing has been done for 3 years in this field and there is no possibility of anything being done for 3 years.

That is why the Department has said let us keep on with the pilot-plant operation.

Mr. Secretary, this is not a pilot-plant operation any longer. There has been something indicated that might be done. The Department does not do it.

Now, if it is the fault of the Congress, you might not feel free to say so, but I have no inhibitions.

Mr. AANDAHL. I have been of the belief that before we go into a larger pilot operation than the one we have used on the ionic process, that we need some improvement in the equipment. That improvement has not been coming as rapidly as we would like it to come.

Senator ANDERSON. I do not see why we continue at this snail's pace when we know this snail's pace cannot teach us anything.

The testimony of Mr. Jenkins is that there are better membranes. We do not have them, but there are better membranes. We have better equipment to use it, but we do not have it.

There are plants in other parts of the world that will work better, but we would not look at them. I do not think that is the best evidence of a burning desire to find out. I do not wish to be unkind about it, but is that evidence really that we are going ahead?

Mr. AANDAHL. The only comment that I was going to make was that when we have information about better equipment which can be used by Ionics, probably the next step should be a larger pilot plant.

Senator ANDERSON. But you would not get any information under the present system. This thing is sitting out in Denver.

Mr. AANDAHL. As Mr. Jenkins just outlined, we now have it scheduled for fiscal 1959, just as soon as some money is available. We are operating under the handicap of budgetary limitations.

Senator ANDERSON. Then the announcement of this hearing did serve some useful purpose?

Mr. AANDAHL. Without any question at all. I am very grateful that we are having the hearing.

Senator ANDERSON. Thank you very much.

I do not want to be unkind about this, Mr. Secretary, but a lot of people have wondered why we have not tried to make more substantial progress in this field. It may be that the Congress is not willing to go ahead. Therefore, we may be able to lay some basis of a little better appreciation of it by the Congress.

Mr. AANDAHL. We have budgetary problems in the executive branch that we are struggling with as well as similar problems in the Appropriations Committees of Congress, and we in the Department have tried to do the best we can in selecting the promising work and phases of that that seem to need attention.

We are doing the best we can in wisely expending the money that is made available to us.

Senator ANDERSON. Has this Government contributed any money to these experiments abroad that you have spoken of?

Mr. JENKINS. No, sir.

Senator ANDERSON. Do you not have contract authority which is limited only to the United States?

Mr. JENKINS. The contract authority was extended in 1955 authorizing the expenditure of not to exceed 10 percent of our research and development money abroad.

Senator ANDERSON. Have you spent any money abroad?

Mr. JENKINS. No, sir.

Mr. AANDAHL. We had a contract under negotiation for that purpose, but it was never consummated.

Senator ANDERSON. You do not really need the authority if you are not going to do it. You asked for authority to contract abroad. Did you contract abroad?

Mr. JENKINS. No, sir; we have not contracted abroad yet.

Senator CASE. Mr. Chairman, I wonder if you have explored the possibility of using some of these foreign currencies we have been hearing a lot about on the floor of the Senate these last few days. That is the easiest money to spend abroad that exists today.

Mr. JENKINS. A small amount of money, Senator Case, is being used in that way. I must confess I do not understand how it works, but some $3½ million of funds were appropriated to restore some of the counterpart funds in Israel last year.

The Department of State handles that money. From that money there was about $100,000 that was earmarked for research and development in desalting.

Senator ANDERSON. Tell us what you did with that $100,000.

Mr. JENKINS. It is not our funds; it is the Department of State.

Senator ANDERSON. You mean the Department of State has taken over the desalting program? Mr. Dulles has time for that, too?

Mr. JENKINS. When the appropriation was made the Department of State came to us immediately and asked if we would review and evaluate any research that was proposed in Israel.

Senator ANDERSON. Did you?

Mr. JENKINS. We have an agreement to do so and have evaluated the only one which has been submitted which is on the membrane method and have recommended that they proceed with the work.

We don't know that much will come of it, but certainly they will obtain some know-how and the general profession will gain from it.

Senator ANDERSON. Do I understand the State Department has withheld this $100,000 in counterpart funds from you?

Mr. JENKINS. No.

Senator ANDERSON. Then they are available to you?

Mr. JENKINS. They are not available to us. They are available for expenditure only in Israel by the Israelian Government.

Senator ANDERSON. Most of us have spent some counterpart funds traveling. We know how they are spent. They are there.

There is $100,000 in Israel. What has happened to it? Have you spent any of it or directed the expenditure of it in Israel?

Mr. JENKINS. We have concurred in the expenditure of funds for this one first and only project that has been submitted.

Senator ANDERSON. How much?

Mr. JENKINS. I will have to get that for the record. I am sorry I don't have the amount at this time.

(Mr. Jenkins subsequently submitted the following information:)

The amount is 50,000 Israeli pounds, or about $30,000.

Senator ANDERSON. Is that the only place you have taken any counterpart funds and tried to spend them?

Mr. AANDAHL. Mr. Chairman, it is my understanding that the expenditures of these funds are a function of the State Department. They have consulted with the Office of Saline Water to determine the feasibility of the use to which those funds are going to be put.

Senator ANDERSON. I can only say, Mr. Secretary, that I just do not believe that the desalting process stays in the State Department. That you come with the State Department and ask for your portion of the counterpart funds just as a congressional committee making a tour of Europe arranges to have counterpart funds supplied to it. I think the control is still in the State Department, but the congressional committee gets it.

The only time I have been on one is when I went to Atomic Energy Conference in Geneva. I know counterpart funds were used.

There is constant talk of counterpart funds. We have a provision in the agricultural bill on the floor right now that would make a great deal of money available. Why cannot some of these funds be used to find out what is going on and, secondly, to direct an experiment in these areas of the earth where they have machinery and equipment?

Why would it not be a good idea to say, we want to find out about the use of handling brackish water, desalting seawater, give us some experimental programs and we will use up some of these counterpart funds?

Mr. AANDAHL. I have no objection at all to that approach, but up to the present time counterpart funds have not been made available to the Office of Saline Water for expenditure insofar as they have been used for this purpose.

They have been contracted and spent and committed by the State Department and our only function has been to cooperate with the State

Department and aid in determining the feasibility and the advisability of the thing that is being proposed for overseas operation.

Senator CASE. Mr. Chairman, yesterday I was examining the report of the President on the operation of the Public Law 480 and I noticed that at least half a dozen different agencies of Government were spending counterpart funds.

While there may be no specific authority for the Department of the Interior to reach into that grab bag, if there are some experiments or programs abroad where we could get something, it seems to me it would be a good place to carry on some of this work.

In fact, recently a scientist made the observation to me that one of the best things we could do in this current situation of a world hunt for scientists is to utilize some of the scientific capabilities in some of the European countries.

Mr. Jenkins, isn't there a process that the Dutch have been working on the desalting of water?

Mr. JENKINS. Theirs is another version of the electromembrane process.

Senator CASE. What do you know about the results they have obtained in that process as compared with the one that Ionic, Inc., has been using here?

Mr. JENKINS. The reports which we have from the Dutch indicate that costwise their process has considerable advantage for one main reason, I believe, and that is the capital investment involved.

The Dutch are able to lay down a piece of equipment which will perform the same desalting for about a third, including import taxes, in this country that is charged by Ionics for their work.

I should say in the Ionics equipment, a very large portion, I believe in the neighborhood of 60 or 70 percent of the cost of the water goes into the capital investment and membrane replacement.

Senator CASE. Is the process essentially the same as Ionics, Inc., uses?

Mr. JENKINS. The principle is the same. The equipment is quite different.

Senator CASE. Have you made any detailed study of the Dutch process?

Mr. JENKINS. As much as we have been permitted to make.

Senator CASE. When you say permitted, what do you mean? Who gave you the permission? Who withheld it?

Mr. JENKINS. The Dutch let us see what they wished us to see and no more, because these processes have a patent value and we were able to learn quite a bit about it. We do not have their test results.

Senator CASE. Was that one of the places you visited when you did go abroad?

Mr. JENKINS. Yes, sir; that was a cooperative project in which a number of nations were invited to join. The Department did not feel that we had the authority. The authority was given by act of Congress; apparently the Congress agreed that we didn't have the authority because they gave it to us. By that time the Dutch had all of the subscribers they needed and we then offered to cooperate, but it was too late.

Senator ANDERSON. The plant has not been built, has it?

Mr. JENKINS. Yes, sir.

Senator ANDERSON. The 2-million-gallon plant?

Mr. JENKINS. This is a final production plant. I should make this clear that in this type of process the unit can be increased in size only a limited amount. I don't believe it will ever be possible to have a single unit of this kind more than a few feet in dimension.

To demineralize a large amount of water we simply have multiples of these.

Senator CASE. What would be the capacity of a practical plant using the ionic-membrane process?

Mr. JENKINS. A single stack of the membrane process, according to the last information we have from them, is capable of producing water at the rate of about 1,000 gallons a day, in this general magnitude, on seawater.

Senator CASE. From seawater?

Mr. JENKINS. Yes, sir.

Senator CASE. What about brackish water?

Mr. JENKINS. Depending entirely on the salinity of the original brackish water, the capacity increases as the salinity of the original water is decreased.

Senator CASE. Did you see the press story the other day about the plant that the Hickman process was being used for with a capacity of 500 or 600 gallons per day?

Mr. JENKINS. I am not sure of this particular press story, but we have been in very close touch with Kenneth Hickman, he is one of our consultants on the development of the larger Hickman still and we know that he has been working on this small household still and has met with considerable success.

Senator CASE. The story that I saw, if I remember correctly, suggested that that household still could be built for about $1,500, but in quantity production might get down to $300. Does that correspond with the information you have?

Mr. JENKINS. I think that that is optimistic at the present time, but those are Dr. Hickman's figures.

Senator ANDERSON. Why do you think it is optimistic? What engineering knowledge do you have that makes you think it is optimistic?

Mr. JENKINS. We offered to assist Dr. Hickman in field testing this equipment because it needs testing on different brackish waters and his estimate of preparing another piece of equipment for this field testing was far greater than $1,500.

Senator CASE. Mr. Chairman, I will get that clipping and would like to introduce it later in the record, if I might.

I thought, myself, at the time, that if that could supply a family home with desalted water for $300 a unit, all you would have to do is plug it in like you would an electric refrigerator, that there would be a considerable market for them.

But it will take, I think, some exploitation and demonstration to show that that can be done.

You have to create a demand to get the $1,500 unit down to $300 a unit.

There was one other question I wanted to ask.

Why did you state that the ionic process is the one most suitable for brackish water? Why is not the Hickman process for distillation equally suitable?

Mr. JENKINS. I think my statement was probably not phrased properly. The electric membrane process, also called electrodialysis, is, itself, best adaptable to brackish waters. However, I am not at all sure that it is the most favorable process for use on brackish water.

Senator CASE. Is not the Hickman process the one that we saw demonstrated at Boston?

Mr. JENKINS. Yes, sir.

Senator CASE. Mr. Chairman, I went with some other Members of Congress to Boston a few years ago and saw what I suppose was the first of the Hickman plants. It was a sort of makeshift thing which used a motor from a Eureka vacuum cleaner, I understood, but any way, it did the business and to me it was most intriguing for its potential small- and large-scale operation, I thought, of any process that had been brought to my attention.

I thought that the ionic-membrane process might have values for particular classes of water, but the other, because of a low operating cost and a low maintenance cost, seemed to me to have the most promise of widespread utilization.

Senator ANDERSON. Mr. Secretary, is there anything in either 1 of these 2 bills that would prevent you from going ahead with the department program?

Mr. AANDAHL. No; I don't think so.

Senator ANDERSON. Is there anything in either 1 of these 2 bills which would prevent you from going over to Israel and using counterpart funds?

Mr. AANDAHL. No, sir.

Senator ANDERSON. What the Senator from South Dakota said about other departments using them may be all wrong.

I understood in Japan, for example, the Army had used counterpart funds to purchase laminated timber products of some kind for construction at Guam, Okinawa, and various places. I do not believe the State Department is the only user of counterpart funds.

I think that the bill enacted into law, the act of July 3, 1952, placed this responsibility right in the office of the Secretary of the Interior, not in some office of saline water, but put it in the hands of the Secretary of Interior to do these things and I know that if the Secretary of Interior wanted counterpart funds to go ahead he would not have a bit of trouble.

Senator CASE. In all fairness I should say we provide for the use of counterpart funds and foreign currencies received from the sale of surplus commodities for the procurement of family housing by a special provision in the military construction act in the 84th Congress.

I have in my hand now the report of the President on the operation of Public Law 480 which embraces the program carried on through the use of Public Law 484 on currencies.

At 1 point it says there are 8 uses of sales proceeds. Here is the Department of Agriculture, the Office of Defense Mobilization, the International Cooperative Administration, and Defense Depeartment, the Export-Import Bank, the ICA, the Department of State, the United States Information Agency; all use counterpart funds and under section 104 of Public Law 480, United States obligations abroad may be paid by any agency.

That is subparagraph (f), section 104, that might be worth exploring.

I would think if that doesn't provide ample authority for the Department of the Interior to carry on research programs abroad in this field that that at least is one thing that we ought to incorporate in any legislation reported.

Senator ANDERSON. Yes; I agree with you but if you cannot do it or find you cannot do it, we might be able to get it. It seems to me if there is anything going on abroad that you want to know about, the Department of Interior might ask us for help.

Senator Case calls my attention to section 104 (e), grants for economic development is handled through ICA. That may be the contracting agency that may be used.

Senator CASE. One other country abroad apparently is working in this field, I was handed a clipping from the Rocky Mountain News which says that the South Africans told a conference here that they are building a plant to desalt sea water at the rate of 6 million gallons a day at a cost of only 30 cents per thousand gallons with a further cost reduction likely.

Did the South Africans present a report at the conference that was held in Washington last fall?

Mr. JENKINS. Yes, sir; a very fine report and they have carried on some outstanding work. Their process is this electrodialysis process, patterned almost exactly after the Dutch version. They use a very inexpensive membrane which must be replaced frequently but because of low labor rates this is the economic thing to do there.

In this country, Ionics, Inc., I believe, feels that a more durable, more expensive membrane is needed.

Of course, there is a vast difference in labor rates and cost of equipment.

Furthermore, when Dr. Volckman was here—he was in charge of the work—I recall that he said, in answer to an informal question, that they had expended somewhat in excess of $2 million on the development program on that one problem only. If so, that is as much as our entire program for this year.

Senator ANDERSON. Do you suppose they got that by asking for it or not asking for it?

Mr. JENKINS. This was a gold mine company, not the Government.

Senator ANDERSON. They are also taking it out of uranium, are they not?

Mr. JENKINS. I think so.

Senator ANDERSON. We are paying a pretty good price for uranium. So it comes back eventually to the United States.

What I am trying to say is have we experimented at all with the process they think is good enough to produce it at 30 cents a thousand gallons? Have we built a pilot plant for this process they have experimented with where they think can produce it at 30 cents a thousand gallons?

Mr. JENKINS. No, sir.

Senator ANDERSON. Have we one under contemplation?

Mr. JENKINS. To build that large a plant?

Senator ANDERSON. Yes; to build a pilot plant of the nature they are talking about.

Mr. JENKINS. No, sir.

Senator ANDERSON. Do you not think it is a promising process?

Mr. JENKINS. Yes, sir.

Senator ANDERSON. Why do we not build one?

Mr. JENKINS. I do not know that the economic need is here to build such a plant for that particular process.

Senator ANDERSON. Would 30 cents a thousand gallons appeal to the people of California?

Senator KUCHEL. I do not think there is any question about that.

Mr. JENKINS. I believe I should straighten out a misunderstanding. The South African plant has to do with desalting some brackish water of 4,000 parts per million only. It has nothing to do with desalting sea water.

Senator CASE. The Rocky Mountain News report referred to desalting sea water.

Senator ANDERSON. Do you think the Rocky Mountain News is wrong?

Mr. JENKINS. Yes, sir; I am afraid that it is, as regards sea water.

Senator CASE. They are not going to desalt sea water.

Mr. JENKINS. Not to my knowledge. If so, that is something brandnew, and I feel sure that it won't occur at 30 cents a thousand gallons.

Senator CASE. Was a paper presented by them at this conference?

Mr. JENKINS. Yes, sir.

Senator CASE. What was the name of that conference?

Mr. JENKINS. That was our conference held jointly with the National Research Council, National Academy of Sciences. We called it "Symposium on Saline Water Conversion."

Senator CASE. Do you have a copy of the program of that conference?

Mr. JENKINS. Yes, sir.

Senator ANDERSON. Do you think this plan, if a model of it were constructed in this country, would have any appeal to the problems that the Senator from South Dakota is concerned about? You see, this bill of his provides for the construction of a plant in the Great Plains area to test this out. If the Dutch think enough of it and the South Africans think enough of it to go ahead and build pretty fair size plants, say $2 million for this project alone, what is wrong with our taking a small flyer in this area to see what it can do?

Mr. JENKINS. I do not think there is anything wrong with it. That would be a good thing to do.

Senator ANDERSON. That is what his bill requires. The Department is recommending against this bill.

Mr. JENKINS. I do not believe we need $5 million to do this.

Senator ANDERSON. The Senator from South Dakota is an economizer. I have seen him in action in both the House and Senate. He will not insist on spending $2 million if the job can be done with less.

Mr. AANDAHL. The Department recommendation is not against a pilot plant of that kind.

Senator ANDERSON. Do I understand these South Africans who have put $2 million in it are building a pilot plant?

Mr. JENKINS. They consider this to be a production plant, I believe. I understand they have carried on $2 million worth of pilot work.

Mr. AANDAHL. That takes in an entirely different field.

Senator CASE. Are we talking about the paper that was presented by Mr. Volckman of the National Chemical Research Laboratory, of Pretoria, and W. H. Mayers, of Johannesburg?

Mr. JENKINS. Yes, sir.

Senator CASE. The paper was entitled, "Ion Selective Membrane Research and Electrodialysis Engineering Development in South Africa."

Mr. JENKINS. Yes, sir.

Senator CASE. You heard the paper presented?

Mr. JENKINS. I did not hear the paper. One of my staff was in charge of that session. He is here today, Dr. Gillam, and he can report on it if you like.

Senator ANDERSON. You know about it, Mr. Jenkins?

Mr. JENKINS. Yes. I did not attend that particular session.

Senator CASE. Are you sure it was not for the treatment of sea water? Do you have a copy of the paper here?

Mr. JENKINS. I have a copy of the abstract of the paper. The paper will be published by the National Research Council in the near future.

Senator CASE. If it is an abstract and it is only 1 or 2 pages, I wonder if we cannot place it in the record?

Senator ANDERSON. Yes, I think it can be placed in the record at this point.

(The paper referred to follows:)

ION SELECTIVE MEMBRANE RESEARCH AND ELECTRODIALYSIS ENGINEERING DEVELOPMENT IN SOUTH AFRICA

By O. B. Volckman and W. H. Moyers

From mid-1953 onward, work has been carried out in South Africa to develop the electrodialysis process to meet specific water-desalting problems.

It was realized early that the economics of the process in South Africa were very dependent on the availability of ion-selective membranes having satisfactory cost and life factors. Lack of adequate field trials and data on membrane life indicated the desirability of developing membranes with production costs so low that a lifetime of only 6 to 12 months would still be economic. Extensive development work by the South African Council for Scientific and Industrial Research led to the production of a range of cheap anion and cation selective membranes suitable for brack water desalting. This work was carried out in parallel with a project to develop an electrodialysis plant to desalt, at an economic price, the many millions of gallons of brack water pumped up daily from the Orange Free State gold mines.

In 1954 a group of gold mining companies headed by the Anglo American Corporation of South Africa, Ltd, sponsored the SACSIR development work which led to the field operation by the mining companies and the SACSIR of a 24,000 imperial gallons per day pilot plant from August 1955 to June 1957, and culminated in the decision by the mining companies to erect a 3 million imperial gallons per day plant to the designs of the SACSIR for operation in April 1958, using the membranes developed by the SACSIR and being made by the Permutit Co., England.

The background to the work is briefly reviewed followed by a section on the development of cellulose-based membranes. This is followed by an account of the development of this work with special reference to operating experience and plant design.

More recent work has been concerned with the development by the SACSIR of small units for use on farms and in remote areas. The progress of this work is also reported briefly.

Senator CASE. The urgency of this problem, it seems to me, is greater than I feel the Department of the Interior is letting itself realize.

Now, I know there are policy questions related to budgetary problems and so forth, but there was a table presented to the Senate Committee on Public Works which gave these figures on the increased water requirements in the United States in terms of billions of gallons per day in the United States. In 1900 we required 2 billion gallons per day for rural and farm use. In 1955 it was 5.4 billion. That is 2½ times, more than 2½ times as much.

The municipal requirements in 1900 was 3 billions per day. In 1955, the municipal requirement was 17 billion gallons per day. That is almost six times as much.

The steam-power requirement in 1900 was 3 billion gallons per day. In 1955 it was 42 billion gallons per day. That is over eight times as much.

The private industrial requirement in 1900 was 10 billion gallons per day. In 1955 it was 55 billion gallons per day. That is 5½ time as much.

The irrigation requirement in 1900 was 25 billion gallons per day. In 1955 it was 110 billion gallons per day. That is over four times as much.

That totals up to these figures:

The requirement in 1900 was 45 billion gallons per day. In 1955, 229.4 billion gallons per day.

The projected use, the Senate Committee on Public Works was advised, the projected use based on the trend of our industry and civilization indicates a total 1975 requirement of 377 billion gallons of water per day. That is 377 billion gallons against 229 billion in 1955. The year 1975 is not so far away. The increase of that 150 billion gallons of water per day is itself more than 3 times what the total use was in 1900.

This geometric increase in the demand for water is against a basic supply which is constant unless we increase it by the storage of water or by the utilization of waters, or making waters usable which are not now usable.

So it seems to me that there is a great deal of urgency in this program and I would hope that these hearings might demonstrate that and bring it home to the Members of Congress who are not aware of it and also to the folks in the Bureau of the Budget and to the people in the Department of the Interior who have to pick and choose and make conforming policy.

Senator ANDERSON. I appreciate what you have just said.

I call attention to the fact that in this little committee print which we put out, the memorandum on the saving water conservation problem, we indicated the per capita use of water in 1900 for industrial purposes being 197 gallons and estimated that about 1975 it will be 1,193. Already in 1950 it was over 300. It has been moving very rapidly from here on out.

I have the same fear that the Senator from South Dakota has, that we are not tuned in to the speed with which this water problem is developing. It is developing very, very rapidly, and we ought to be testing devices of every kind that seem to offer promise.

If this process which seems to appeal to these people in the Union of South Africa is promising, we ought to either try that or try something similar to that on a large enough scale so that we learn more than we have learned from the plant that operated a short time in Miller, and a short time in Arizona, and then went into cold storage in Denver and it virtually went into cold storage. A thousand hours in 3 years is not much use.

Mr. JENKINS. May I make a comment?

Senator ANDERSON. Yes.

Mr. JENKINS. In my office, we have tried to follow the policy which has been laid out in the beginning by our advisers and those with whom we conferred, of working on processes that need further development and when someone else with private funds takes over and develops something, that merely helps us conserve our little appropriations for other purposes.

Now, this has occurred, you see, with the Dutch and the South African work and even the Ionics work where they have placed equipment in commercial production. We have not felt that it was necessary expenditure of our very small appropriation to duplicate what they were doing. We used it for other purposes.

Senator ANDERSON. I appreciate you have to follow your advisers, but I cannot help but express the hope that your advisers do not get you in the same category as the man who swallowed his spoon and thereafter could not stir.

I am sure I hope this thing starts to move around here. I do not feel it has moved very fast.

Here is this brackish water subject. You say this process seems to be the best, yet you have not done anything in the way of trying to improve the machinery that was put into the plant 4 years ago.

There are improvements in other parts of the world. Nobody has looked at them. There are claims being made steadily that these things can be reduced and can work.

I think you may need a lot more money but I think you are going to have to ask for it. This problem is likely to be extremely serious.

As I say, I do not believe it is as expensive as we think because it might solve our other problems which are also expensive. It is not exactly cheap to develop some of the water systems that are now being proposed. There was a time when I do not believe the Subcommittee on Reclamation of the Interior Committee ever was presented with a problem on municipal water supply. Yet as we well know, we have reported out a few bills that are almost entirely municipal water supply, something unheard of in the history of this committee.

I think something is needed in that direction.

Do you have any testimony on sea water, Mr. Jenkins? What do you think is developing in sea water? Are there processes there that are not being adequately tested in this country?

Mr. JENKINS. Not that we know of. There is this one very attractive process on which we are working. We have referred to it as the W. L. Badger long tube vertical distillation process. We have discussed that earlier today. Dr. Badger will refer to that at some length later.

Then there is an adaptation of what is known as the flash distillation process, in which warm water is used in a single-stage flash operation. We have advanced that with the cooperation of Griscom-Russell Co. I believe they will report at these hearings.

On that process we believe that the next step is definitely the design and construction of a pilot plant. That would be a large plant. It is not adaptable to small plants. I do not know how large; Griscom-Russell can say.

Senator ANDERSON. How soon do you think they could build such a plant?

Mr. JENKINS. It depends on whether there is a need for the water at a particular place that can pay the cost——

Senator ANDERSON. Tell me what you think is a fair price for water at a particular place where they can pay——

Mr. JENKINS. This process gives promising——

Senator ANDERSON. No. You always go off on the theory you do not know whether they can afford to pay for water. What is your yardstick of what they can afford to pay for water? What do you think would be an attractive price? How much per thousand gallons on the west coast of California?

Mr. JENKINS. We have used as a yardstick the maximum prices known to be paid for municipal raw water in quantities, not bottled water or water shipped in during drought.

Senator ANDERSON. Give me a figure. I want pennies.

Mr. JENKINS. That is about $100 an acre-foot.

Senator ANDERSON. Now you are off from the thousand gallons.

Mr. JENKINS. Thirty cents a thousand gallons.

Senator ANDERSON. Senator Kuchel, do you think there are any municipalities in California that would be interested in a cost a little bit more than that?

Senator KUCHEL. Let me say this. I have been trying to think of the projects which this committee and the Congress have approved for California under which at the moment Congress is annually appropriating great sums.

We have under construction the Trinity River project that is a quarter of a billion dollars. We have before this committee a bill to provide for the construction of a reservoir, $300 million. We have in various parts of the State a 30-million-gallon Ventura project. We have two water projects in Santa Barbara County.

The amounts of the Federal expenditures I do not know. The State legislature is at the moment faced with a $1,500 million project which represents but a piece of an $11 billion program.

I must say that the basic problem without whose solution we cannot support our economy is that of water and, yes, there is no question that costs must be comparative, Mr. Chairman. I have an idea that if we did not have any water we would be willing to pay for anything that would provide water.

Senator ANDERSON. You have towns where they are hauling it in in tank cars.

Senator KUCHEL. Even today. I am quite enthusiastic in support of this type of legislation. I do not see in regard to our peacetime problems in America where we could spend money more wisely than in this field.

Senator CASE. Mr. Chairman, on that cost, I think my home town of Custer, which is a small town, you pay a dollar and a half and you get 2,000 gallons. For each additional thousand gallons you pay 50 cents. That, of course, is for the water as they get it.

But you take in a community where they have a comparable water rate they are paying that for hard water that requires detergents to use for laundry purposes or acts up on the plumbing, 30 cents per thousand gallons to convert that into soft water would be regarded as cheap.

Senator ANDERSON. I also say you have to take some of these chances. I asked a scientist how long would it have taken to have built the original atomic bomb if we had tested every step as we went along. He said we would have done it in 75 years easily. But we had to do it in 3. They took a lot of chances. If it had not worked there might have been some red faces.

Mr. AANDAHL. I do not think the statement that Mr. Jenkins made was fully responsive to the thought in mind when you asked the question, when do you think we might have a pilot plant on the flash evaporation process.

I do not think our determination to go ahead with the pilot plant would depend on whether or not there was a market for the water at the price that this process might produce it at. The thing I would be concerned about is whether or not that process had the possibility of showing some marked improvement on other processes or the way in which the process had been used before and the next pilot plant there may be just an intermediate step in getting to the goal of production of water at the low price that we ultimately want.

Senator ANDERSON. Yes, Mr. Secretary. To prove that—I seem to be in a one-track mind this morning—I go to the Shippingport reactor which has just been turned on in Pennsylvania, the cause of great pride to everybody. It was supposed to cost $37 million. It got up to $55 million, and then $70 million. I think the total cost is going to be $100 million if all the costs were attributed to it. The current from it is going to run 90 mills per kilowatt-hour. They could have generated the same current for 7 or 8 mills, probably a little less than that in the Ohio Valley, but for some unaccountable reason they though it worthwhile to build a plant that cost $50 million more than the 30 or 35 million dollars estimated. It is going to produce power far beyond the cost of ordinary power, and the Federal Government is going to have all that power piped into the lines of the Duquesne Power & Light Co. and charge them only what it would have cost if they had used steam. They must be wanting to develop something and they are willing to pay a big price to develop it.

I do not question that. I commend it. It seems to me that if this plant you are talking about might not produce water as cheaply as we would hope to produce it, we would learn something out of its construction.

If you just checked what happened to the plant that was built in the Senator from California's home State by Pacific Gas & Electric, when they got through with this small atomic plant they discovered it would not generate what they thought it would but possibly almost twice as much as they thought it would. It is more promising than

they ever dreamed and so they have offered to build a 60,000-kilowatt plant. The engineers think it is a very foolish proposition. They think they should build a 200,000-kilowatt plant because the things they learn as they go along develop so rapidly that they believe it is going to be possible to do things they badly need.

I think we need a little bit of that enthusiasm, whether it is the problem of brackish water in one part of the country, and I am pretty sure we need it in the development of domestic water from seawater.

I think that the appropriations which you have listed here, Mr. Secretary, showing that the growth of appropriation is rather slow, that you asked for $1,195,000 for fiscal year 1958, only got $725,000 from the Congress, may be due to the fact that the Congress thinks you were not bold enough and gambler enough in taking chances.

This year, the House approved $785,000. You got about what you asked for. If you wish to go faster than that you should ask for more, and I think you are going to take some chances. I believe they want to see some plants built and I know the Senator from South Dakota and I would like very much to see different things tried in a sizable plant.

It undoubtedly will cost some money. It undoubtedly will not come down to the lowest possible figure, but the day will come when these engineers and scientists will have an idea and come in saying, "I know another way to do it" and the price will come down. We need it badly in the United States. We can avoid a lot of nasty fights over waterholes in the West if we can get this done. We can eliminate some interstate competition and intrastate in the great State of California.

Senator KUCHEL. Maybe I can have less bruises after each session of Congress.

Senator ANDERSON. I know what you go through on each project. I think that is important. I do think that certain areas of the United States are having a population ceiling put on them right now by their water situation. If we could change that I think it would be very much worthwhile.

Mr. AANDAHL. I would like to say, Mr. Chairman, I am thoroughly in accord with that point of view.

As you notice by that statement I am definitely recommending that we proceed with pilot plant testing and go into larger pilot plant as our experience justifies. It is for that reason that I wanted to modify the limited answer that Mr. Jenkins gave.

I do not think our pilot-plant construction should be dependent on immediately reaching the ultimate goal. We have to have some intermediate steps.

Senator KUCHEL. Let me ask you this. If the Congress felt that there was a need for a rapid increase in the research and development in this field and if the Congress therefore were to approve one or both of these bills, could you not indicate to the committee that the Department would acquiesce in the feeling that Congress might have in taking such action?

Mr. AANDAHL. I would say that as far as I am concerned, personally, I would be very appreciative of any incentive that the Congress might give to the research and development work in saline water.

Senator KUCHEL. I want to say, Mr. Chairman, that this is a responsibility which the Congress now can face up to. Here are two

pieces of legislation which you two gentlemen have introduced. I would hope that we could spread on the record the indispensable necessity for congressional action and I am sure that the Secretary has indicated a cooperation to proceed.

Senator ANDERSON. I am convinced that the Secretary of Interior is just as friendly toward the idea as you are, Mr. Secretary.

Mr. AANDAHL. There is no question about that at all.

Senator ANDERSON. I am happy that the two of you have taken that position.

The communication from Senator Knowland that I referred to earlier will be placed in the record at this point.

(The letter referred to follows:)

LETTER FROM SENATOR WILLIAM F. KNOWLAND

UNITED STATES SENATE,
COMMITTEE ON APPROPRIATIONS,
March 20, 1958.

Hon. CLINTON P. ANDERSON,
Chairman, Senate Subcommittee on Irrigation and Reclamation,
Senate Interior Committee, Washington, D. C.

DEAR MR. CHAIRMAN: The Nation's daily consumption of water used for all purposes has increased tremendously since the turn of the century. The increased need for water occasioned by our rapidly growing population, expanding industries, and developing agriculture has lifted per capita consumption threefold since 1900. By 1975 it is estimated that the figure will rise by another 100 per cent.

Availability of good water in plentiful quantity has been responsible to a great extent for the material progress of the United States since the Nation's beginnings.

While nearly every community in the country originally was well supplied with water resources, today many centers are increasingly concerned by present and potential problems resulting from dwindling water supplies.

Congress in 1952 recognized and responded to the danger, by voting funds for a special study to determine methods for processing the unlimited waters of the seas, and of inland brackish sources, so as to render them fit for human consumption and for industrial and agricultural uses.

This work, conducted by the Office of Saline Water Research in the Department of the Interior, has developed several methods for converting presently unusable waters and although some of these methods have shown more promise of practical application than others, none of them has yet been tested on a large-scale basis.

I welcome this opportunity to join with others who, appearing before this subcommittee, perceive the importance of furthering the testing of saline-conversion methods and I am glad to join in urging the Congress to immediately authorize the establishment of pilot-conversion plants to accomplish this objective. With demands upon the national water supply increasing every day, we must not lose any opportunity now available to improve our experimentally developed processes to see whether they can be utilized on an economically feasible basis. Success in such efforts would far outweigh, through eventual benefits to our entire economy, the investment of the $10 million required to set up and operate this project.

For this reason and because the 14 million citizens of my State of California are foremost among those Americans acutely concerned with the disastrous consequences of limited and vanishing water supplies, I support the legislation before this subcommittee, Senate bill 3370 and Senate Joint Resolution 135, which together propose that there be established one or more full-scale demonstration plants "for the production of water suitable for agricultural, industrial,

municipal and other beneficial consumptive uses, through the utilization of the most promising saline-water conversion processes currently under study in the Department of the Interior."

Sincerely yours,

WILLIAM F. KNOWLAND.

Senator ANDERSON. Congressman Teague has sent a letter enclosing a series of telegrams from Santa Barbara which, unless they duplicate the ones put in already by the Senator from California, will go in the record at this point.

(The documents referred to follow:)

LETTER FROM CONGRESSMAN CHARLES M. TEAGUE

HOUSE OF REPRESENTATIVES,
Washington, D. C., March 20, 1958.

Hon. JAMES E. MURRAY,
United States Senator, Chairman, Committee on Interior and Insular Affairs, United States Senate, Washington, D. C.

DEAR SENATOR MURRAY: It is my pleasure to transmit to the Senate Committee on Interior and Insular Affairs for inclusion in the record of hearings on Senate Joint Resolution 135 the attached telegrams from (1) Mid-Coastal Counties State Water Plan Board, over the signature of J. E. Lewis, clerk of said board, and (2) Santa Barbara County Water Agency, over the signature of C. W. Bradbury, chairman.

I heartily endorse the representations presented in these two wires.

Respectfully submitted.

CHARLES M. TEAGUE,
Member of Congress.

SANTA BARBARA, CALIF., *March 19, 1958.*

Congressman CHARLES M. TEAGUE,
House of Representatives,
Washington, D. C.:

We urge your favorable support of the following communication sent this date to G. W. Lineweaver, committee assistant, care of Senator Clinton Anderson:

The undersigned, Mid-Coastal Counties State Water Plan Board, which is an official agency of and represents the California counties of San Luis Obispo, Santa Barbara, and Ventura, urges the passage of Senate Joint Resolution 135 providing for conversion of sea water.

This board further urges the construction of said conversion plant in 1 of the 3 above-mentioned coastal counties for the following reasons:

1. The said three counties have developed and are using all available sources and supplies of water within the area and are experiencing a rapid growth in population, agricultural, and industrial development for which it is vitally necessary that additional sources of water be developed.

2. There are extensive military installations in the area of the three counties among which are Camp Roberts and Cambria Air Force radar station in San Luis Obispo County, Oxnard Air Force Base, Point Hueneme Naval Base, and point Mugu Naval Missile Base in Ventura County, and the great new missile base being developed at Cooke Air Force Base in Santa Barbara County which base alone will require, according to the officers in charge, 5 million gallons of water per day. In addition, an Air Force radar station is planned for Santa Barbara County which will require approximately 100,000 gallons per day. Also, numerous defense industries in this area are drawing heavily on our overtaxed limited water supply.

We again respectfully urge that the proposed sea water conversion facilities be located in the area of the aforementioned coastal counties.

MID-COASTAL COUNTIES STATE WATER PLAN BOARD,
By J. E. LEWIS, *Clerk of Said Board.*

SANTA BARBARA, CALIF., *March 19, 1958.*

Congressman CHARLES M. TEAGUE,
House of Representatives, Washington, D. C.:

We urge your favorable support of the following communication sent March 17, 1958, to G. W. Lineweaver, committee assistant, care of Senator Clinton Anderson.

The Santa Barbara County Water Agency regrets that due to the shortness of time it is unable to take advantage of your kind invitation to appear and present testimony on Senate Joint Resolution 135 and respectfully requests that this telegram be accepted in evidence as its testimony.

This agency is a political subdivision of the State of California empowered to provide a water supply for the land and inhabitants within the county of Santa Barbara.

The agency has been informed that Senate Joint Resolution 135 contemplates an experiment in salt-water conversion in the State of California from which some quantity of potable water may be derived.

We wish to respectfully suggest the reasons why the county of Santa Barbara is a suitable site for said plant.

The county of Santa Barbara is located on the south central coast of California. It has an estimated present population of 125,000. The climate is semiarid and water supply is, and always had been precarious, being dependent entirely upon the occurrence and amount of local rainfall which is gathered, when it occurs, in surface and subsurface storage facilities. The rainfall is characterized by alternate cycle of wet and dry seasons. In dry cycles acute shortages are experienced which have necessitated drastic rationing of water.

The economy of the county is agricultural, light industrial, residential and oil production. The principal agricultural crops are citrus, avocados, and vegetables.

The county of Santa Barbara has been experiencing the phenomenal population growth of southern California with consequent increased demand for water. Local water sources have been fully exploited and no outside source of supply is available.

All these circumstances are fully set forth in House of Representatives Document 587 prepared by the United States Bureau of Reclamation in connection with its Santa Barbara County water plan.

As part of this plan, the Bureau of Reclamation has completed the Cachuma project at a cost of $43,360,000. Returnable from revenues from the sale of water to the Santa Barbara County Water Agency.

The supply from this project is to be obtained by impounding and distributing the winter flows of the Santa Ynez River by means of Cachuma Dam. This dam has a maximum capacity of about 205,000 acre-feet of water. About one-third of that amount is now in storage.

Cachuma Dam is located about 45.7 miles upstream from the mouth of the Santa Ynez River. The Santa Ynez River runs from east to west, paralleling the Pacific coast, but separated therefrom by the Santa Ynez range of mountains. The mouth of the river is at the Pacific Ocean and within area of the Cooke Air Force Base.

The water to be obtained from Cachuma project has been allocated by the California State Water Rights Board among users in Santa Ynez Valley and the coastal region, including the city of Santa Barbara. In the testimony of the United States Bureau of Reclamation before the State water rights board it was estimated that under most favorable circumstances the supply available from the Cachuma project will fail to meet the ultimate needs of its users. The estimated ultimate shortage is 20,610 acre-feet per year.

There is no other available source from which this deficit can be compensated.

A major consumer of Santa Ynez River water is the permanent Cooke Air Force Base located west of the city of Lompoc. The officer in charge of the engineering facilities estimates the peak requirements of the base at 5 million gallons of water per day. This is equal to the consumption of a city of approximately 30,000 people.

Though most of the area of the Cooke base is beyond the watershed of the Santa Ynez River its present supply is derived from wells in the riverbed.

Since the base is a permanent installation, an adequate water supply is essential. This additional demand will impair the supply available for civilian use from the common source of supply.

Conclusion: The location of the proposed salt-water conversion plant in the county of Santa Barbara will best serve the public interest, national and local.

(1) Any water derived therefrom will benefit the national defense by contributing to the water supply of Cooke Air Force Base.

(2) Such additional supply will lessen the gravity of the civilian water supply shortage in the area, which is recognized by the United States Government to be acute.

(3) Since storage is presently available in the United States Bureau of Reclamation Cachuma Reservoir the cost of providing storage for the converted water will be avoided.

It is respectfully urged that the conversion project be located in the county of Santa Barbara, Calif.

Signed: C. W. BRADBURY,
Chairman, County Courthouse, Santa Barbara, Calif.

Senator ANDERSON. Mr. Secretary, would it suit you if we called the general witnesses this afternoon and then came back with questions of the Geological Survey and the Bureau of Reclamation, unless they have prepared statements.

Mr. AANDAHL. I think they are prepared to make an oral summary of what has been submitted by either, I believe yesterday. That information was a little late in coming up.

Senator ANDERSON. What I thought, Mr. Secretary, was that many of these witnesses have come from out of town. I thought we might take them this afternoon and tomorrow. Then if we wanted to go back to the Bureau of Reclamation for additional testimony we do it against a better background and information already supplied us by these general witnesses.

Mr. AANDAHL. We will be glad to come back at the wishes of the committee.

Senator ANDERSON. If you are tied up at your office, Mr. Secretary, you need not come back.

The meeting will then adjourn until 2 o'clock and Mr. Kennedy, Harold Kennedy, county counsel of California, will be the first witness and others may find out from Mr. Lineweaver about when they will be called.

(At 12:20 p. m., a recess was taken until 2 p. m.)

AFTERNOON SESSION

Senator ANDERSON. The hearing will be in order.

Mr. Kennedy?

Would you state for the record your name and your connection with the Los Angeles area?

STATEMENT OF HAROLD W. KENNEDY, COUNTY COUNSEL OF THE COUNTY OF LOS ANGELES, AND ATTORNEY FOR THE LOS ANGELES COUNTY FLOOD CONTROL DISTRICT

Mr. KENNEDY. Mr. Chairman, my name is Harold W. Kennedy. I am the county counsel, that is, the county attorney for the county of Los Angeles and attorney for the Los Angeles County Flood Control and Conservation District.

I am here appearing before this committee in support of Senator Anderson's resolution 135, upon the unanimous vote of all five of the members of the Los Angeles County Board of Supervisors. I am a little unhappy with the role in which I am placed in being the first general witness. I have debated as to the approach I should take to

the matter. I have concluded that I will not have fulfilled my assignment as far as the Los Angeles County government is concerned unless I speak quite frankly here this afternoon.

I would like to say as a prelude that I have been a longtime career man in government and I am always happy when I can agree with my colleagues in government. As a public law officer, trained in moderate statements, I do not like to speak critically of representatives of any unit of government, but I feel that I will not have fulfilled my responsibility against the backdrop of the tremendous interest in this problem in Los Angeles County in California, and throughout the arid West if I don't say rather frankly that I was greatly disappointed, somewhat shocked, at the testimony that was presented by the Office of Saline Waters and by the Department of Interior here this morning.

It would be presumptuous on my part to get out of my field of the law and public policy and engage in a discussion as to the technical phases of this problem. But in the preparation of my paper, which, Mr. Chairman, I ask be incorporated in the record in full—it is only 9 pages in addition to my supplementary statement—I had believed that my role would be to support the Department in their approval of going forward for this comparatively modest amount of money to build a demonstration plant for the purpose of making further progress in the technology of converting sea water.

I must state that, as pointed out by Senator Kuchel of California, whom we respect and admire and whom I have worked with since he first was a member of the California Legislature, that we are taking this water problem pretty seriously in California. One of the assignments of the county counsel is the legislative representative of the county, both at Sacramento and in Washington. Therefore, for 3½ years I have been intensively engaged in an attempted solution of California's water problem, working with the county board's problem, and have spent a good many hours in connection with it.

Why do I say that? Because by way of background as to the importance that we attach to your resolution, there were some statistics given here this morning by Senator Kuchel. I believe the Senator made reference to some. I secured from the statistical division of one of our county departments, before leaving, the present estimated population of Los Angeles County. We are crowding 6 million people—14,317,000 in all of California—every day coming to Los Angeles, not as tourists or to visit but to stay, it is estimated about 529 people. That is 15,000 a month.

Put it in terms of an annual figure it is around 187,000 people. It is equivalent to the 1950 population of a city the size of Salt Lake.

And so just to simplify it, every year, because we are in the sweep of that vast industrial empire, whether we like it or not, we are going to get a population equivalent to a city the size of Salt Lake in Los Angeles County alone.

Los Angeles County, as we meet here today, is larger in population than 39 separate States of the Union. And so you see we cannot do anything other than make sure that for the future, when this explosive growth line crosses the line of diminishing returns, and

where there is a need for supplemental water, we must be sure, from one source or another, that we have that water.

Senator ANDERSON. I wonder if I may break in with a personal question.

In 1935 I had Los Angeles County as one of my areas of responsibility in connection with Mr. Hopkins' Federal relief administration. One of our projects was known as the Hyperion storm sewer. It was so big and bulky that a lot of people said it was way, way beyond the needs of the community. Has it proved to be?

Mr. KENNEDY. It is entirely inadequate. Sewage is one of the pressing problems along with all the other growing pains.

Senator ANDERSON. In other words, what was way too big for Los Angeles and bound to be impossibly too large is already too small, and you are adding a city of the size of Salt Lake, or the expanded population of Albuquerque which finally after many years got up to 180,000; you add one like that every year and digest it in Los Angeles County?

Mr. KENNEDY. Yes, sir. So, you see, a county with that population, with a budget of $565 million with 35,000 employees, building a $300 million freeway program costing more than a million dollars a mile, does not think that $10 million for a demonstraton plant to desalt the Pacific is comparatively very much money.

By way of example, the California Legislature just last week—and I think that your joint resolution can take credit for 335,000 of it—there had already been put in the budget for the University of California's division studying this problem, $86,500. Last week the Finance Committee, against a backdrop of economy, added another $335,000, making in the aggregate $421,500 for the continued study of sea-water conversion.

Just to show the feeling of the people with respect to this matter, the interesting sequence of events that took place since the introduction of your resolution on the 9th day of January, immediately thereafter the board of supervisors, as I have recited, went on record firmly supporting this resolution, instructing the county counsel to support it, and sending to all of the members of the congressional delegation from California a copy of the board's resolution.

Then within a few days there was introduced in the California Senate, on February 4, 1958, by Senators Robert I. McCarthy, of San Francisco, and Senator Richard Richards, of Los Angeles County, Calif., Senate Joint Resolution No. 4, making reference to Senator Anderson's resolution, and then reciting:

> Whereas the county of Los Angeles has transmitted to Senator Anderson a request that southern California be chosen as the site of the proposed demonstration plant; and
>
> Whereas southern California is probably the most logical place in the country for the location of such a plant, in view of its coastal location and its urgent need for water to supplement its supply from other sources: now, therefore, be it
>
> *Resolved by the Senate and Assembly of the State of California, jointly,* That the Legislature of the State of California respectfully memorializes the President and the Congress of the United States to take the necessary steps to make southern California the site of the proposed $10 million sea-water conversion test plant.

The point to be emphasized there, they assumed, as a matter of policy, that the money would be made available by the Congress

and that there would be a demonstration plant placed someplace, and the point of inquiry in this resolution, assuming that to be in evidence, is: Where shall we put it?

And then we have received a whole deluge of letters, requests, and so on. It may be of surprise to the author of the resolution. I read from the Antelope Valley Ledger-Gazette, Wednesday, March 12, 1958, under the heading: "Ask $10 Million Sea Water Plant for Antelope Valley" that "B. P. Glenn, Lancaster Chamber of Commerce secretary-manager, this morning confirmed that the groundwork has been laid for the location of the plant in Antelope Valley."

So, you see, Senator, the people are really ahead of the thinking here today in this committee.

Then a letter from the retiring president of the Calabasas Chamber of Commerce, Mr. E. J. Smith, pointing out seriously that the logical place is along the Malibu coast, and making the argument that the water, if demonstrated there, would be put to beneficial use. I would like that letter inserted in the record.

(The letter is as follows:)

LETTER FROM E. J. SMITH, RETIRED PRESIDENT, CALABASAS CHAMBER OF COMMERCE

CALABASAS, CALIF., *March 17, 1958.*

Mr. HAROLD KENNEDY,
Washington, D. C.

DEAR SIR: I am writing on behalf of the citizens of the Las Virgenes area of Los Angeles County. On February 25 the proposal to form the Las Virgenes Municipal Water District passed by a substantial majority. The district has not yet been certified; consequently, the newly elected directors cannot yet speak for the area.

We feel that this area, along with Malibu and Topanga, have the greatest need for water and the location to utilize a salt-water conversion plant to the greatest advantage. The construction of such a plant on the Malibu coastal area would enable this whole retarded area to develop for the greatest good for Los Angeles County. Therefore, we ask that you make an effort to secure the proposed Federal funds (for the construction of a salt-water conversion plant) for the Las Virgenes, Topanga, Malibu areas.

I am enclosing a map of the Las Virgenes Municipal Water District to give you a clear picture of our area.

A point that we feel should be taken into consideration in regard to the location of this plant is the fact that the Las Virgenes area will be a reception area in the event of any major disaster in Los Angeles. We would have thousands of displaced people to take care of, and probably the major water-supply lines for the Los Angeles metropolitan area would be disrupted. Another point is periodical great property loss caused by fire in the mountains of the area. A water supply through the area would enable the Los Angeles County Fire Department to more easily control such fires, saving millions of dollars in fire damage.

Anticipating your cooperation, we hope for great success in your mission to Washington.

Respectfully,

E. J. SMITH,
Retired President, Calabasas Chamber of Commerce.

P. S.—It is my understanding that the purpose of appropriating Federal funds to build a demonstration salt-water conversion plant is to prove the practical use of this method of solving water problems in the United States. Many islands in various parts of the world are now being supplied water by use of salt-water conversion. Catalina Island would merely be another such use. Our area using salt-water conversion would be a major step in proving the practical use of this process on the mainland.

E. J. SMITH.

Senator ANDERSON. I think I should say that at the conclusion of your remarks I would like to put into the record a telegram from Agoura in which he says:

The Malibu region could serve a much more heavily populated area of Los Angeles that is without water.

And a wire from Earl S. Bennett, living in the same community, which I thought was a blunt as a telegram could be. He said, addressed to me:

Demonstrate some horsesense, Senator. Put that salt-water conversion plan on the Malibu coastline.

I assume that is a very direct and forthright expression of the feelings of the matter.

Those telegrams and several others addressed to me and the staff will be included in the record at the end of your remarks.

If your statement was at all vigorous, you would have to only turn to the House hearings of the Subcommittee on Appropriations, the House of Representatives, starting at page 43, and there are about 10 pages there in which I would say that they were a little bit impatient, and a little rough on the office, perhaps, of saline water, because more headway has not been made.

I think the only thing I would try to prove by it is that Congress would agree in general with the position that you have taken, that we ought to do something with this, building a plant, and get on with it. I am surprised as you are when we seem to sense that there are individuals who seem to think we must take it very, very slowly and be sure of every step before we take it. I don't believe the water problem of California is going to wait and that there may be other areas of the country that will be similarly affected.

Mr. KENNEDY. Philosophically we are in the same situation that the city and county of Los Angeles was in way back when that great engineer, William Mulholland, was pioneering in the Owens Valley and in the Colorado River. They had before the people what at that time was a large bond issue with respect to bringing water down from the Owens River. He said very bluntly, "If you don't get the water, you won't need it."

I think to seek to attach an economic feasibility report to this $10 million, and take the position that because economically you could not justify the $10 million for X gallons of water or X acre-feet that it was not both wise and prudent to go forward, it seems to me it is almost like saying what is the price of a glass of water to an enriched gold miner at a water hole who is dying of thirst.

In other words, all of these things are comparative. I don't want to overdramatize the situation but it is the responsibility of people in Government to furnish the leadership to have facilities ready when they are needed, and we cannot, and will not, permit the tragedy to happen in California.

I should also at this point make it clear, because in the enthusiasm in the press and elsewhere that came out of your resolution many people were afraid that it would be misinterpreted at Sacramento and in Washington; that the county of Los Angeles, in supporting this, was cooling off with respect to its rights on either the Colorado River or the Feather River, and that is not the case.

In other words, we believe we must develop our water resources from their most logical sources, and the nearest cheapest place to get supplemental water in southern California is from the Feather River, 625 miles away. We have already processed our people to spend $1,600 million for that one project and started immediately to talk about building a project on the Klamath or the Eel. The thing we have to be sure about is whenever this explosive growth line does cross the diminishing returns line, that the water is there. So we feel that this measure setting up this money in a very practical way makes progress in that situation.

We feel that the thing that is needed is an aggressive action program, and that that $10 million expenditure of public money is very good insurance to protect against a catastrophe.

I would like to make reference to an article by a man who stands very well in the scientific field in California, Prof. Jack E. McKee, professor of sanitary engineering, California Institute of Technology, in the article which he calls Desalting the Pacific, and it has recently been reprinted in the Engineering and Science Monthly for February of 1958, published at the California Institute of Technology. When I have finished reading three paragraphs from it I will hand it to the clerk for such purposes as you will need for the record.

I think this is somewhat in point, in view of the testimony here this morning:

> Certainly, the desalting of sea water is one of the most challenging and fascinating problems ever faced by scientists and engineers. Until recently, its solution was not too urgent; but with increasing pressure from population growth throughout the world, and with larger and larger per capita use of fresh water as our civilization becomes more industrialized, the problem has been brought into sharp focus.
>
> In military activities, where expense is not a consideration, the desalting of sea water is a practical and accomplished fact * * *
>
> On Iwo Jima, during World War II, the entire supply of drinking and cooking water for more than 30,000 Army, Navy, and Marine personnel was produced by various types of distillation units. This method of producing fresh water is also used aboard many ships.

Then going further:

> Distillation units are already employed for municipal water supply where no other sources are available. At Curacao in the Dutch West Indies, a population of 45,000 is supplied with fresh water by a 6-stage evaporator having a capacity of 770,000 gallons per day. At Kuwait on the Persian Gulf, and at Aruba, near Venezuela, similar distillation units are employed to supply these oil-producing communities. Even in California, the Pacific Gas & Electric Co. distills 144,000 gallons per day of fresh water from the ocean. * * *

Then going over to the last paragraph of this article, under "Conclusions," reading from page 6:

> By technological improvements, it is remotely conceivable that desalinization of sea water can be accomplished for $125 to $150 an acre-foot in the next 5 or 10 years * * *

Senator ANDERSON. That is about the figure that the Office of Saline Water used this morning, wasn't it, the Assistant Secretary, about $125 an acre-foot, as a possible feasible level? So apparently the professor agrees that that is a goal that could be reached within the next 5 or 10 years.

Mr. KENNEDY. That is what he says.

And then, if you compare that, Senator Anderson, with the estimated cost of the Feather River water brought 625 miles at the intake

at the distribution point in Los Angeles County, they are thinking in terms of at least $45 to $50 an acre-foot.

And so if, on the basis of the technological improvements referred to by Professor McKee, the cost of water as we know it in California does not seem to me that to be thinking in terms of water at from $125 to $150 an acre-foot is too far away from getting it off of the drafting board out of the trailer unit like they had at Denver, and into a demonstration plant that will show from a practical standpoint engineeringwise, economically, comparative cost data evaluations, what you can do.

I am a little confused as to the breaking point between research, per se, a pilot plant, per se, and a demonstration plant. I just don't know where the framework of those different categories would be. But as far as the representatives of Los Angeles County are concerned, we stand firmly in support of this appropriation.

I had 2 or 3 other references which I would like to make.

(The above-mentioned article entitled "Desalting the Pacific," is on file with the committee.)

Mr. KENNEDY. Also included in my instructions at the request of the city of Avalon, Catalina Island, I wish also to place into the record the offer that has been made by the people of the city of Avalon to enthusiastically embrace as a joint enterprise the building of such a plant on Catalina Island. It would be completely within Congressman Cecil King's H. R. 11405, which is designed after Congressman Engle's bill and would make a joint enterprise between the Federal Government and the State of California for such project.

Senator ANDERSON. Would you mind if I read a portion of Mr. Engle's statement?

Mr. KENNEDY. I hadn't seen Mr. Engle's statement; it just got over this morning.

Senator ANDERSON. He said:

> I noticed, Mr. Chairman, that one of the approaches listed in your announcement of these hearings related to desalting of sea water in coastal areas in cooperation with State and local agencies. I was particularly interested in this because it constitutes the major difference between your bill, on which these hearings are being held, and the bill I have introduced.
>
> In my opinion, the State of California has a greater interest in this program than any other State or area of the Nation at the present time simply because the water situation there is more critical and because California's future economy depends so heavily upon an adequate supply of water. The California Department of Water Resources has a special unit working in this field and several committees of the California Legislature are also studying the matter.
>
> For this reason, it seems to me that a joint venture between the Federal Government and the State of California would be appropriate, with the cost being borne equally between the two. I believe that the State of California is able and willing to join the Federal Government in this undertaking, and I expect complementary legislation to be introduced in the State legislature.

Would you wish to comment on the possibility that this might become a joint venture?

Frankly, I did not put it in a joint-venture category because I was not trying to prejudge where such a plant should be built.

I have a feeling that there may be people in New York that may want someday to look at the possibility they may need more water, and there may be a great many other cities along the Atlantic seacoast that feel that way about it. I myself have been greatly attracted to the desirability of perhaps doing this near Los Angeles and, as I

have previously indicated, went so far as to ask the Atomic Energy people to see if there should not be a possible combination between those two, because you know a tremendous lot of atomic energy research is now going on in California.

We rely a great deal upon your institutions. I thought I would like to have any comments you would care to make on this.

Mr. KENNEDY. I would like to make one further comment with respect to the argument that Avalon advocates, and I think it is sound.

As I have already said, I don't think we need to look at the economic feasibility of the cost of this water. Actually its purpose would be served even in an area where there was a present adequate supply of supplemental water, where the water serves the purpose of proving to a lot of people that it was reasonably potable, that you could grow some vegetables with it, and that the mineral salts that were left in it after the salts were taken out were not too heavy but what you could still, say, grow some alfalfa.

And so, in Avalon, they having a dire need for water now, the money would be well spent because they immediately would put to a beneficial use economically the water that was produced.

As far as California law is concerned, all that would be necessary would be for the California Legislature to pass an enabling statute that would authorize any city or county or any special district such as a water district to make that a legal expenditure of public money to join with the Federal Government or the State in a joint project.

My appraisal of the political situation, public-policywise, would be that there is so much interest in it that the California Legislature would be right for taking such action, and it would not be a difficult thing at all.

The resolution by Senators McCarthy and Richards was unanimously approved and enthusiastically endorsed and widely commented upon by the press in California. And so I think it is a very practical thing because it would then assure that as a partner in the program a legal entity was enthusiastic about it and would join with the Federal Government, with the Department in such a proposal.

I am sure that you will be getting letters from many other places. Some of my friends in Ventura County that have been working on it phoned me and asked me to state also that Ventura County would be pleased to be considered as a possible location for a site.

In my concept I think the important thing is to get the money for a demonstration plant somewhere, and not get in a quarrel and let the thing crack up because there were many petitioners for the locale of the site.

In closing my statement, I would like to read a portion of my paper. I would like to add a philosophic observation.

If we go back over Arnold Toynbee's dismal recital of the long history of government and study comparatively the approximately 20 civilizations that have come into being and survived maybe for centuries, and then pass from the historical scene, a detailed study will show that some of them passed from the historical scene because they ran out of water.

I testified earlier this week in behalf of Los Angeles County for an air-pollution control device, on the economics of this thing. The

figures are fresh in my mind. In 9 years, in public and private money, in Los Angeles County alone, we have spent $73 million to get cleaner air.

Water is our No. 1 problem in California and in Los Angeles County. So in our thinking this $10 million that is being asked for in Senate Joint Resolution 135 doesn't appear to be comparatively very big to people who on October 1, 1957, junked millions of dollars worth of incinerators because they couldn't burn rubbish in their backyards any more.

We forced, by reasonable rules, industry to spend $49,500,000 in a 9-year period to be in strict compliance. So if we are willing to spend that for cleaner air, I believe that you will find universal support for spending $10 million to get more water.

Senator ANDERSON. Couldn't we say, in view of the fact that if the $10 million resulted in a good plant, that that plant would benefit not only the area in which it would have to be built but any other area similarly situated on either coast of this country, or on any coast of any other country?

Mr. KENNEDY. Yes, sir.

Senator ANDERSON. And that there may be areas of the earth, where we are trying our very best to get agreement and understanding and appreciation of the American way of doing things, that might be very happy to have a system whereby they could obtain good drinking water from the ocean?

Mr. KENNEDY. Yes, sir. I think in a very realistic way, of the money projects that are being considered by Congress, here is one that has less aspects of provincialism, because whatever is done will benefit people everywhere.

Pursuant to the unanimous instructions of the five members of the board of supervisors of the county of Los Angeles, as county counsel and legislative representative for the county, I am appearing in behalf of Senate Joint Resolution 135 providing for the construction by the Department of the Interior of a demonstration plant for the production from the sea or other saline waters, of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses.

Along with many citizens and leaders in California, the board of supervisors of the county of Los Angeles is genuinely interested in the possibilities of desalting sea water from the Pacific Ocean and making it available for domestic, industrial, and agricultural use. Indicative of this interest was the instruction given to me by the board of supervisors some months ago to contact leaders in the field of sea-water conversion and engineering companies engaged in the manufacture and construction of sea-water conversion equipment in the belief that California's great need for water dictated following every possible source.

On January 22, 1958, the county counsel received the following instruction from the board of supervisors:

> At the meeting of the board of supervisors on January 21, 1958, Supervisor Hahn called attention to Senate Joint Resolution 135 which calls for an appropriation of $10 million for a prototype plant for conversion of sea water to fresh water. An order was adopted instructing you to communicate with the members of the proper committee and the California congressional delegation and inform them of the board's concurrence.

The board of supervisors of Los Angeles County again on March 11, 1958, reaffirmed its former interest in Senator Anderson's Senate Joint Resolution 135 and instructed me to accept the invitation extended by Senator Anderson and appear at the hearing of the Subcommittee on Irrigation and Reclamation of the Committee on Interior and Insular Affairs and actively support the Federal appropriation of $10 million for the express purpose of building a sea water conversion demonstration plant for the production of fresh water from salt water.

In the meantime as unusual interest had been shown on the part of the citizens of the city of Avalon, located on Santa Catalina Island, 20 miles off the Los Angeles County coast, on motion of Supervisor Burton W. Chace, chairman of the board of supervisors, and representing the city of Avalon, the county counsel was further instructed to place on record with the subcommittee of the Congress and with the Office of Saline Water in the Department of the Interior the hope that the city of Avalon that such demonstration plant would be located on Santa Catalina Island. Santa Catalina Island is one of the best known and most beautiful resorts in the world, and its growth and development and economy have been restricted largely because of the lack of an adequate supply of fresh water.

The people in the city of Avalon make the logical argument that to build a demonstration plant would put such water as was converted to an immediate beneficial use, in addition to an opportunity to prove its potability to a very large number of people, as well as demonstrate its usefulness for domestic, industrial, and agricultural purposes.

Therefore, it is the official position of the county of Los Angeles that it strongly advocates and supports such an appropriation for the purposes set forth in Senate Joint Resolution 135.

In common with mankind in general, the 5½ million people in Los Angeles County and the approximately 14,317,000 people in California (recently estimated and based upon figures from the United States Census Bureau, the director of finnace of the State of California, and the California Taxpayers Association) are intrigued as people have been for centuries in the possibilities of looking to the inexhaustible sea as a source of supply for fresh water.

In accordance with the Board's desire that information be furnished to them and to the people of Los Angeles County respecting the engineering and economic possibilities of the conversion of sea water, during the past 6 months I have conferred with the following authorities and experts in the field of sea water conversion and sea water conversion engineering:

1. Mr. David S. Jenkins, Director of the Office of Saline Water, Department of the Interior;
2. Mr. Everett Howe, professor of engineering, University of California at Berkeley;
3. Mr. Jack E. McKee, professor, sanitary engineering, California Institute of Technology;
4. Mr. Harvey O. Banks, director, Department of Water Resources, Sacramento.

And with official representatives of:

1. Maxim Silencer Co., of Hartford, Conn.;
2. The Griscom-Russell Co., of Massillion, Ohio;
3. Cleaver-Brooks Co., of Milwaukee, Wis.

The problem is aptly stated by Prof. Jack E. McKee, of the California Institute of Technology, in his article, Desalting the Pacific.

> Certainly, the desalting of sea water is one of the most challenging and fascinating problems ever faced by scientists and engineers. Until recently, its solution was not too urgent; but with increasing pressure from population growth throughout the world, and with larger and larger per capita use of fresh water as our civilization becomes more industrialized, the problem has been brought into sharp focus.

There appears to be considerable agreement among the experts that from an engineering standpoint it is practical to desalt sea water by several known methods; that there are several sizable communities throughout the world that are almost entirely dependent upon converted sea water; that successful sea water conversion has been undertaken by sea borne units (where fuel was immediately available and cost no item) but that it would be unrealistic to claim that at the present time sea water could be considered economically practical to compete with the normal and conventional sources of supply. At least as far as California is concerned, everyone who has studied the problem clearly understands that in no sense can sea water be considered in competition with water from the Owens River Valley, the Colorado River, the Feather River, or the North Coastal Basin of California—such as from the Eel or Klamath Rivers.

However, this does not mean that the time has not arrived for a demonstration of the most likely engineering method or methods in order that further progress may be made in man's determination to ultimately get water from the sea. It is within that philosophy that the board of supervisors of the county of Los Angeles is giving active support to Senator Anderson's proposal in the belief that out of such a demonstration plant further scientific and engineering data will be secured, comparative cost prices developed, and a great deal more learned about the economic practicability of sea water conversion.

In giving such encouragement, the county of Los Angeles is mindful that in several instances in the past ridiculously low prices have been quoted for desalting sea water. It, therefore, shares the view taken by the Department of the Interior's Office of Saline Water that it is important to standardize methods of computing costs, to take into account maintenance, depreciation, and interest on the capital investment, as well as power or heat costs. The argument, therefore, can be made that out of a demonstration plant as conceived by Senator Anderson will probably come very valuable data both on the engineering and economic side.

We support as a wise and practical expenditure the sum of $10 million or such amount as is adequately necessary for such a demonstration plant, having in mind the spirited controversy that is going on among the experts as to whether or not it would be better to spend such an amount in further scientific research in the hope of finding "a scientist's break-through" in this field.

Our position is that the activities of the Office of Saline Water in the exclusively scientific field should be continued and supported, but that as a supplemental activity a practical demonstration is also required.

Like all pioneering efforts in the field of sea water conversion, increasing encouragement has come as the technology has improved. In support of Senate Joint Resolution 135, it might be recalled that

until a few years ago, research in the desalting of sea water was sporadic and uncoordinated.

In 1952, however, the Congress of the United States recognized the importance of this problem and passed Public Law 448. This action authorized the Secretary of the Interior to develop practical low-cost means of producing from sea water, or from other saline waters, fresh water of a quality suitable for agriculture and for industrial, municipal, and other beneficial consumptive uses.

The initial appropriation was $2 million for a 5-year period, extending to June 1957. The last Congress extended the program for an additional 5 years and has increased the money value of the research to a total of $10 million or $2 million per year. To assist the Secretary of the Interior in broad policy methods, an advisory group was named consisting of nine highly qualified persons in various fields related to the program.

It is a matter of common knowledge that the active and diligent program developed by Mr. David S. Jenkins, director of the Office of Saline Water of the Department of the Interior has made great progress in the whole field. Therefore, it is logical at the present time to make this comparatively modest sum of money available for the location, construction and maintenance of an adequate demonstration plant for the production of fresh water. Surely, such a demonstration plant would justify itself for the reasons already recited as being in the best interest of the people of the United States.

Attention of the Subcommittee on Irrigation and Reclamation is respectfully called in the interesting sequence of events taking place in California and elsewhere subsequent to the introdutcion by Senator Clinton P. Anderson of Senate Joint Resolution 135 on January 9, 1958. As already recited, the board of supervisors of Los Angeles County approved the measure on January 22, 1958. On February 4, 1958, there was introduced by Senators Robert I. McCarthy and Richard Richards in the California Senate Joint Resolution No. 4 reading as follows:

Whereas Senator Clinton P. Anderson, of New Mexico, has recently made a request in Congress for an appropriation of $10 million for the construction of a full-scale demonstration plant for the production from sea water of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses through the utilization of the ionic-membrane process or 1 of the 3 most promising saline-water conversion processes currently under study in the Department of the Interior; and

Whereas the county of Los Angeles has transmitted to Senator Anderson a request that southern California be chosen as the site of the proposed demonstration plant; and

Whereas southern California is probably the most logical place in the country for the location of such a plant in view of its coastal location and its urgent need for water to supplement its supply from other sources: Now, therefore, be it

Resolved by the Senate and Assembly of the State of California, jointly, That the Legislature of the State of California respectfully memorializes the President and the Congress of the United States to take the necessary steps to make southern California the site of the proposed $10 million sea water conversion test plant; and be it further

Resolved, That the Secretary of the Senate be directed to transmit copies of this resolution to the President and Vice President of the United States, to the Speaker of the House of Representatives, and to each Senator and Representative from California in the Congress of the United States.

On February 10, 1958, Congressman Clair Engle introduced H. R. 10606 in the House of Representatives, a similar bill to supplement the Saline Water Act of 1952, providing for construction of a large-scale demonstration plant for the production of fresh water from salt water.

Congressman Engle's bill makes the very practical proposal that would authorize the Secretary of the Interior to negotiate and enter into agreements with the State of California for the construction and operation of a large-scale conversion plant designed to produce not less than 10 million gallons of fresh water per day.

His bill further provides that the demonstration plant may be constructed in combination with a steam electric powerplant or a nuclear reactor as the source of thermal energy, if it is determined that such addition will result in the reduction of conversion costs. This is wise, of course, as the big expense item in sea water conversion is the cost of power or energy.

In order that there may be no misunderstanding as to the position of the county of Los Angeles it should be cautioned that in no sense are we of the opinion that practical and economic sea-water conversion is near enough to think in terms of substituting a sea-water conversion project for the presently contemplated $1,500 million Feather River project already approved by the California Legislature. Neither should those outside of California gain the impression that California in any respect is receding in its insistence upon its rightful share of water from the Colorado River.

The official position of the county of Los Angeles could be summarized as follows:

1. The county is interested in keeping accurately and intelligently informed respecting all possible sources of water in this field.

2. The county clearly recognizes that the technological and economical aspect of sea-water conversion to date do not justify even remotely considering it as a substitute for the Feather River project or any other statewide projects planned for the reasonable future. The county of Los Angeles is interested in having further engineering and economical experimentation engaged in by public and private agencies, and we believe—I will add parenthetically—that the additional activities or the present activities of the Office of Saline Water should continue to be supported, but that this be a separate and distinct project.

3. The board of supervisors did on January 21, 1958, officially endorse Senator Anderson's Senate Joint Resolution 135 calling for an appropriation of $10 million for a prototype plant and further experimentation in the conversion of sea water to fresh water, and the county counsel was instructed to communicate with and advise members of the California delegation of the county's interest in the matter.

4. Southern California has been built on a desert, or at least on the edge of a desert. It is destined inevitably to become a vast industrial empire. Because it has a great need for domestic water, and has agriculture and industry, Los Angeles County particularly would be an exceptionally good place to demonstrate the practical use of sea water. I believe that your records will show that application has already been made by the city of Avalon, the Malibu area on

the Los Angeles coast, and the counties of Ventura and San Diego that consideration be given by the Office of Saline Water to such sites as meeting all of the essential requirements. The important thing, of course, is to build an adequate demonstration plant at some logical place. I am sure that the benefits conceived by the sponsors and supporters of this bill would be fruitful irrespective of where the test was made.

Looking at the problem in its broadest and deepest aspects and having in mind the great explosive growth that is taking place in California and throughout the world, aggressive steps must be taken to assure that sufficient supplemental water will be developed to prevent the taps running dry when the explosive growth line crosses the point of limited water supplies.

We must not forget that in the long history of man that civilization started at a stream, and that a study of the civilization that have come into the world during its 6,000 years of recorded history shows several of them passed from the historical scene because of an exhausted water supply.

That, however, is in the past, but I believe that Senator Anderson was looking toward the future when on January 9, 1958, on the floor of the Senate he explained his concept of the far-reaching effect which a successful sea-water conversion program would have upon our relations with other nations; where he pointed out the decided attractiveness of this program to nations in the Middle East and that "a contribution to the water supply in that part of the world might be of vastly greater long-range importance than the arming of the various nations with atomic weapons * * *."

I am sure that many Americans will agree with him that "wars can be laid aside, policies neutralized, and bargains made when water is at stake."

Senator ANDERSON. Thank you very much, Mr. Kennedy, for your statement. You have given me quite a lift by your comments.

(The telegrams and communications referred to by Senator Anderson are as follow:)

TELEGRAM FROM EARL S. BENNETT

AGOURA, CALIF., *March 18, 1958.*

Senator CLINTON ANDERSON,
United States Senate, Washington, D. C.:

Demonstrate some horsesense Senator. Put that salt-water conversion plan on the Malibu coastline.

EARL S. BENNETT.

TELEGRAM FROM PETER TEWKSBURY

AGOURA, CALIF., *March 18, 1958.*

Senator CLINTON ANDERSON,
United States Senate, Washington, D. C.:

Suggest more thought be given to location of proposed Catalina salt-water conversion plant. Plant in Malibu region could serve much more heavily populated area northwest of Los Angeles that is now virtually without water. Latter is only direction Los Angeles can expand but growth now stymied by water starvation.

PETER TEWKSBURY.

TELEGRAM FROM AVALON CATALINA CHAMBER OF COMMERCE

LONG BEACH, CALIF., *March 18, 1958.*

Senator CLINTON ANDERSON,
Washington, D. C.:

We strongly urge favorable consideration of bill H. R. 11405, any other plan to locate pilot salt water conversion plant on Santa Catalina Island. Unique island location will eliminate local rivalries inevitable if mainland location chosen. Value of water produced will be greater here. Ideal environment for project of experimental nature. Need here is immediate—southern California peak shortage years in future. We strongly urge consideration on its merits of locating a salt water conservation plant on Catalina Island.

AVALON CATALINA ISLAND CHAMBER OF COMMERCE.

TELEGRAM FROM MIDCOASTAL COUNTIES STATE WATER PLAN BOARD

SANTA BARBARA, CALIF., *March 19, 1958.*

G. W. LINEWEAVER,
Committee Assistant,
Care of Senator Clinton Anderson,
Senate Office Building, Washington, D. C.:

The undersigned Midcoastal Counties State Water Plan Board, which is an official agency of and represents the California Counties of San Luis Obispo, Santa Barbara, and Ventura, urges the passage of Senate Joint Resolution 135 providing for conversion of sea water.

This board further urges the construction of said conversion plant in 1 of the 3 above-mentioned coastal counties for the following reasons:

1. The said three counties have developed and are using all available sources and supplies of water within the area and are experiencing a rapid growth in population, agricultural and industrial development for which it is vitally necessary that additional sources of water be developed.

2. There are extensive military installations in the area of the three counties among which are Camp Roberts and Cambria Air Force Radar Station in San Luis Obispo County, Oxnard Air Force Base, Point Hueneme Naval Base, and Point Mugu Naval Missile Base in Ventura County, and the great new missile base being developed at Cooke Air Force Base in Santa Barbara County, which base alone will require, according to the officers in charge, 5 million gallons of water per day. In addition, an Air Force radar station is planned for Santa Barbara County which will require approximately 100,000 gallons per day. Also, numerous defense industries in this area are drawing heavily on our overtaxed limited water supply.

We again respectfully urge that the proposed sea water conversion facilities be located in the area of the aforementioned coastal counties.

MIDCOASTAL COUNTIES STATE WATER PLAN BOARD,
By J. E. LEWIS, *Clerk.*

TELEGRAM FROM SANTA BARBARA (CALIF.) COUNTY WATER AGENCY

SANTA BARBARA, CALIF., *March 17, 1958.*

G. W. LINEWEAVER,
Committee Assistant,
Care of Senator Clinton Anderson,
Senate Office Building, Washington, D. C.:

The Santa Barbara County Water Agency regrets that due to the shortness of time it is unable to take advantage of your kind invitation to appear and present testimony on Senate Joint Resolution 135 and respectfully requests that this telegram be accepted in evidence as its testimony.

This agency is a political subdivision of the State of California empowered to provide a water supply for the land and inhabitants within the county of Santa Barbara.

The agency has been informed that Senate Joint Resolution 135 contemplates an experiment in salt water conversion in the State of California from which some quantity of potable water may be derived.

We wish to respectfully suggest the reasons why the county of Santa Barbara is a suitable site for said plant.

The county of Santa Barbara is located on the south central coast of California. It has an estimated present population of 125,000. The climate is semiarid and water supply is and always has been precarious, being dependent entirely upon the occurrence and amount of local rainfall which is gathered, when it occurs, in surface and subsurface storage facilities. The rainfall is characterized by alternate cycles of wet and dry seasons. In dry cycles acute shortages are experienced which have necessitated drastic rationing of water.

The economy of the county is agricultural, light industrial, residential, and oil production. The principal agricultural crops are citrus, avocados, and vegetables.

The county of Santa Barbara has been experiencing the phenomenal population growth of southern California with consequent increased demand for water. Local water sources have been fully exploited and no outside source of supply is available.

All these circumstances are fully set forth in House Document 587 prepared by the United States Bureau of Reclamation in connection with its Santa Barbara County water plan.

As part of this plan the Bureau of Reclamation has completed the Cachuma project at a cost of $43,360,000 returnable from revenues from the sale of water to the Santa Barbara County Water Agency.

The supply from this project is to be obtained by impounding and distributing the winter flows of the Santa Ynez River by means of Cachuma Dam. This dam has a maximum capacity of about 205,000 acre-feet of water. About one-third of that amount is now in storage.

Cachuma Dam is located about 45.7 miles upstream from the mouth of the Santa Ynez River. The Santa Ynez River runs from east to west paralleling the Pacific coast, but separated therefrom by the Santa Ynez range of mountains. The mouth of the river is at the Pacific Ocean and within area of the Cooke Air Force Base.

The water to be obtained from Cachuma project has been allocated by the California State Water Rights Board among users in Santa Ynez Valley and the coastal region including the city of Santa Barbara. In the testimony of the United States Bureau of Reclamation before the State water rights board it was estimated that under most favorable circumstances the supply available from the Cachuma project will fail to meet the ultimate needs of its users. The estimated ultimate shortage is 20,610 acre-feet per year.

There is no other available source from which this deficit can be compensated.

A major consumer of Santa Ynez River water is the permanent Cooke Air Force Base located west of the city of Lompoc. The officer in charge of the engineering facilities estimates the peak requirements of the base at 5 million gallons of water per day. This is equal to the consumption of a city of approximately 30,000 people.

Though most of the area of the Cooke Base is beyond the watershed of the Santa Ynez River its present supply is derived from wells in the riverbed.

Since the base is a permanent installation an adequate water supply is essential. This additional demand will impair the supply available for civilian use from the common source of supply.

Conclusion: The location of the proposed salt-water conversion plant in the county of Santa Barbara will best serve the public interest, national and local.

(1) Any water derived therefrom will benefit the national defense by contributing to the water supply of Cooke Air Force Base.

(2) Such additional supply will lessen the gravity of the civilian water-supply shortage in the area which is recognized by the United States Government to be acute.

(3) Since storage is presently available in the United States Bureau of Reclamation Cachuma Reservoir the cost of providing storage for the converted water will be avoided.

It is respectfully urged that the conversion project be located in the county of Santa Barbara, Calif.

C. W. BRADBURY,
Chairman, Courthouse, Santa Barbara, Calif.

Senator ANDERSON. Our next witness is Mr. Fritz Lawaetz, and Mr. Boreham. Mr. Lawaetz is chairman of the public works committee, Virgin Islands.

I am glad to welcome you, particularly as you are chairman of the Public Works Committee of the Virgin Island Senate.

STATEMENT OF FRITZ LAWAETZ, CHAIRMAN, PUBLIC WORKS COMMITTEE, VIRGIN ISLANDS SENATE, ACCOMPANIED BY DONALD BOREHAM, COMMITTEE OF PUBLIC WORKS, VIRGIN ISLANDS

Mr. LAWAETZ. I have before me two statements that have been presented to this committee. One deals with potable water, by your assistant, Mr. Lineweaver—one that you are familiar with. The other was presented by Mr. Anthony Lausi, Director of Territories, and deals with water problems on St. Thomas, V. I. These two statements go into the details of the water problem of the island of St. Thomas.

Mr. Boreham, who is the commissioner of public works and has all the records, will be able to inform you of the different costs and expenses.

(Mr. Boreham presented the following table:)

POTABLE WATER, FISCAL YEAR 1957

Month	Water pumped, gallons	Water in storage, gallons	Approximate days' supply	Rainfall, inches, average	This year	Water used, 6 heaviest consumers							Water lifts			Total gallons
						Virgin Islands Hotel	Hospital	Pearson Gardens	Yacht Haven	Blue-beard's Hotel	Berg's Homes	Total	Virgin Islands government	Other	Total	
July 1956	4,453,950			3.68	0.63	2,609,750	297,500	471,880		106,500		3,485,630				
August 1956	5,505,570	3,262,900	16	4.42	5.27	1,253,250	165,750	335,180		45,000		1,799,180	2		2	491,600
September 1956	3,608,280	2,214,350	11	5.57	2.23	1,286,750	250,500	223,850		98,250		1,859,350	3		3	745,000
October 1956	4,537,170	2,436,820	12	6.31	4.43	1,104,050	107,260	121,930		75,750		1,408,990				
November 1956	4,756,170	3,381,960	17	5.62	3.21	1,621,490	243,840	369,270		130,000		2,364,600				
December 1956	3,999,540	1,538,800	7½	3.08	1.73	1,422,170	292,820	402,470		65,750		2,183,210	5		5	1,239,000
January 1957	3,399,640	785,600	4	3.02	1.91	1,467,310	206,590	318,870		87,000		2,079,770	11	6	17	4,061,800
February 1957	4,336,320	917,175	4½	2.20	1.61	1,595,350	171,640	353,240		95,250		2,215,480	7	9	16	3,905,000
March 1957	4,699,170	1,123,485	5½	1.92	1.49	1,523,280	200,290	400,290		99,750		2,223,610	10	12	22	4,875,500
April 1957	4,880,750	1,315,400	6½	2.41	.80	1,378,080	232,220	551,990		91,500	76,000	2,329,790	10	14	24	5,309,000
May 1957	5,016,360	2,320,390	11½	4.01	1.58	1,623,860	222,020	465,590		87,600		2,399,070	18	15	33	6,307,600
June 1957	4,682,010	3,687,000	18½	3.01	2.89	1,147,870	230,380	378,540		101,800	38,000	1,896,590	15	14	29	6,257,400
Average		2,089,440	10½													
Total	53,874,930			45.25	27.78	18,033,210	2,620,810	4,393,100		1,084,150	114,000	26,245,270	81	70	151	33,191,900

POTABLE WATER, FISCAL YEAR 1958

July 1957	5,106,490	5,173,500	26	3.68	1.01	1,675,340	384,950	510,510		93,900	57,700	2,722,400	18	12	30	6,627,600
August 1957	5,199,230	6,914,585	34½	4.42	3.65	994,490	88,480	385,050		82,400	25,200	1,575,620	15	10	25	5,523,000
September 1957	5,554,640	6,268,600	31½	5.57	4.80	835,290	200,140	384,450		111,200		1,531,080	6	2	8	1,966,400
October 1957	4,165,220	5,493,550	27½	6.31	2.98	759,530	156,930	131,190		56,800	112,200	1,216,650	14		14	3,441,200
November 1957	4,081,940	5,510,620	27½	5.62	2.73	988,420	225,990	444,190		120,200	159,000	1,937,800	9	7	16	3,932,800
December 1957	6,238,670	5,674,220	29	3.08	6.69	1,001,620	179,810	391,670	226,200	91,000	18,700	1,909,000	4	4	8	1,966,400
January 1958	4,687,450	7,894,050	39	3.02	4.76	1,161,600	141,090	272,530	58,300	70,200		1,703,720		11	11	2,703,800
February 1958	4,001,570	7,514,310	37½	2.20	.80	958,060	181,040	36,980	35,100	172,900	81,100	1,465,180	1	5	6	1,474,800
Average		6,316,680	31½													
Total	39,035,210			33.90	27.42	8,374,350	1,558,430	2,556,570	319,600	798,600	453,900	14,061,450	67	51	118	27,656,000

Mr. LAWAETZ. As you know, under the organic act of 1954, certain amounts of moneys were given to the legislature and the people of the Virgin Islands for such things as schools, roads, hospitals, et cetera. However, due to our economic difficulties in the islands, it became necessary to take from this money approximately half a million dollars during the fiscal year 1956–57 to transport water into the island of St. Thomas.

With the large influx of tourists, industry is coming into the islands. The former way of getting water by catchment was inadequate, and it was necessary for us to bring in water from Puerto Rico, about 50 miles away.

In the island of St. Croix, my island, where I am chairman of the soil-conservation board, we have solved some of our water problems by building dams, to which Congress has so graciously given us contributions each year. These dams have helped us to raise the water table in this island, and we have been able to support the population and get water for our industries, as well as for the large influx of tourists into our islands.

However, we find, even in St. Croix, places where we have not been able to find saltless water, where private people are building distillation plants. There is one person who built a plant last year, the first experimental plant of its kind in St. Croix, with a capacity of about 1,200 gallons a day. We do not know how satisfactory it will be.

On the island of St. John, where the Caneel Bay development, tourist resort, sponsored by Mr. Rockefeller, they are putting up a distillation plant that will produce 15,000 gallons a day. However, in the island of St. Thomas, an island with a very rapid runoff, we find from the soil-conservation viewpoint that it is nearly impossible to retain water in earth dams, as the structure of the material is very porous and not suitable for dams. It has, therefore, become necessary to look into other phases of getting water for our area.

We took the runway and used that as a catchment area to help supplement some of the water. However, we have been faced with severe drought during the last 2 years, with a rainfall of only about 27 inches. And the rainfall coming off in a period of 2 or 3 weeks, that fills all available catchments, and often the water may run off from the runway without having sufficient capacity to hold it in.

We have had the Navy come in in emergencies to help us bring in water when our barge could not take care of the needs.

As you may know, the Interior Department has an agency over there known as the Virgin Islands Corporation, that runs our powerplant and also runs the sugarcane industry of the island of St. Croix that went into bankruptcy in 1930.

The power situation in St. Thomas has shown up to be very badly in need of improvement. It was the thinking of the Interior and, as a matter of fact, of the Virgin Islands, that, if we could get a plant into the Virgin Islands that would be a dual-purpose one generating electricity and at the same time distilling water, at a cost of about $2 million, this could probably solve our problem.

Not knowing the cost of such an operation, it will be necessary when we meet in April, if Congress will see fit to give this money, that we will pass legislation to find how we can make this work economically whereby the island pays its share of expenses.

Senator ANDERSON. I don't seem to remember exactly what it was, but a very short time ago someone mentioned the fact that in, I think, Los Angeles, in connection with some new electrical plants, there will be a large amount of water distilled.

Mr. LAWAETZ. The plant that was suggested to us by the Department of the Interior will produce up to about 200,000 gallons a day, which is about what is used at the present time. However, we have large catchments and other facilities where we could store about 12 million gallons. So, if there should be a small surplus beyond the 250,000 gallons that we are probably using today, we will have storage to put in this additional water.

As you also know, we are located right at the seashore and the Navy has a base down there to which they would also come in during emergencies if water is needed.

It would be our intention to put this factory up at the base, which has been turned over to the Virgin Islands Corporation at this time, where we have filtration plants and a majority of our storage tanks. I think, with this in mind, Mr. Boreham can probably give you better detail of the actual cost in the community from day to day.

As I said before, we have had to pull from the funds that you allocated to us for public-works improvement so as to keep the people supplied with water. We have done this with very water-conscious people. Sometimes in the streets, where the poorer class of people get water, we only open the valves for a few hours a day when we are running short of water, so that the bulk of tourists that come to our islands—that is our economy, as you may know—may not leave us because they couldn't get a bath.

Senator ANDERSON. Mr. Boreham?

Mr. BOREHAM. I would like to add a few statistics to the statement made by Senator Lawaetz, based on records that we have kept accurately over the last 2 years. As you know, the population of St. Thomas is about 14,000 people, not including tourists that come and go. I would like to submit at this time a map of the submarine base in St. Thomas, showing the location of where the new plant could be built, and its relation to our underground storage tanks. It is within a quarter mile of where the plant could go.

(The map referred to was filed with the committee.)

Mr. BOREHAM. Consumption of water has been increasing by leaps and bounds, primarily due to the improvement in the standard of living, plus the influx of tourists.

From actual records kept by the department of public works, water consumed from the so-called public potable water-supply system in fiscal year 1954 amounted to 33½ million gallons.

In fiscal 1955, it had jumped to 41 million gallons.

In 1957, that jumped further up to 53¾ million gallons. And for the first 8 months of the current fiscal year we have already consumed 39 million gallons, which means that we will probably use about 60 million gallons this year.

As a result of the terrific drought of the last few years, we have been forced to haul water from the island of Puerto Rico. We get it from the naval base at Roosevelt Roads.

In 1954 fiscal year, the rainfall, which closely approached the average, was 44 inches. In 1955 it was 43½ inches. And, in 1957, one of

the worst droughts we have ever had, the annual rainfall dropped to 27¾ inches.

For the current fiscal year, the first 8 months, we have only had 27½ inches of rainfall, and we are now in our dry period. Chances are we will get practically no more rain before the hurricane season, which starts in July.

To supplement such water as we could catch from our catchment areas, of which there are 35 acres, and a storage capacity of 12½ million gallons, we have been obliged to haul water not only by our own barge and tug, but we have had to rent commercial carriers to bring it in.

In the fiscal year 1956, which was a comparatively wet year, we only had to haul in 6,600,000 gallons.

Senator ANDERSON. How much has that water been costing you that you hauled in?

Mr. BOREHAM. At the time about $6.25 a thousand gallons, and that does not include the cost of processing and distribution. That is merely the cost of picking it up in Puerto Rico and pumping it into our system.

Senator ANDERSON. So that 30 cents a thousand gallons would be a step in the right direction, wouldn't it?

Mr. BOREHAM. We would hardly believe it, Senator.

Senator ANDERSON. Even if it took a little while to get there, it would be all right. Would you be at all interested in a portion of a plant that supplemented what you already had?

Mr. BOREHAM. Yes, sir.

Senator ANDERSON. An experimental plant might be small.

Mr. BOREHAM. We wouldn't like one of these "eye-dropper plants." I don't mean to be facetious. We argue, Senator, that, if we can get something that will produce about 300,000 gallons of water a day, it would probably solve our water problem for maybe the next 5 or 10 years, perhaps.

Senator ANDERSON. You say you bring in a fair amount of water?

Mr. BOREHAM. That is right.

Senator ANDERSON. At an extremely high price. Therefore, the demonstration of feasibility isn't quite so difficult in your case. You don't have to put it against the price of $40 an acre-foot or something of that nature, as you would in an American city.

Mr. BOREHAM. To complete the record, in 1957 we hauled in 33 million gallons. In the first 8 months of the current fiscal year, we have hauled in 27½ million gallons, all at a cost of about, an average, of $6 a thousand gallons.

Senator ANDERSON. Did the Department of the Interior conduct a solar evaporation down there?

Mr. BOREHAM. Yes, sir; we had a small one.

Senator ANDERSON. Do you know what the experience was? Were the results decisive at all?

Mr. BOREHAM. First of all, I think it was a little too expensive for us. We need so very much water we would have to have a vast area of glass. Next, we built the experimental plants, one in St. John, one in St. Thomas, and we would have had to have a police force the size of New York City to prevent the kids from breaking the glass.

Personally, I changed probably dozens of panes of glass. I can't tell you what the attraction was, but that is what happened.

Senator ANDERSON. Nobody can tell what the attraction is of a deserted building somewhere. The kids soon find it and break the windows.

Mr. BOREHAM. BB guns and everything else. We had a terrible time. We had to abandon it. Not that it didn't work; it worked all right, but we just had to abandon it. We can't afford the cost. In fiscal 1957 we spent $220,000 in hauling water from Puerto Rico. In the first 8 months of this year we have spent $98,000. The reduction there has been due to a little more careful operation of the barge system. Originally the barge would make about three trips a week. We have it down so that we are hauling five trips a week.

That is all, sir, unless you want to ask me any questions.

Senator ANDERSON. Do you feel that the development of potable drinking water from sea water is a desirable goal, and if it can be achieved it should be speedily achieved, if possible?

Mr. BOREHAM. Tomorrow, sir, if we can.

Senator ANDERSON. Thank you very much for coming up.

Dr. W. L. Badger, consulting engineer, Ann Arbor, Mich. We are glad to have you.

STATEMENT OF W. L. BADGER, CONSULTING ENGINEER, ANN ARBOR, MICH.

Mr. BADGER. I have 4 or 5 slides that I would like to show you.

Senator ANDERSON. We would be happy to see them. Would you first state for the record your name and your connections?

Mr. BADGER. I am W. L. Badger, independent consulting engineer, Ann Arbor, Mich. For your information, Mr. Chairman, I have had 40 years of experience in the design and construction and operation of evaporator plants all over the world.

This is a highly diagrammatic scheme of the process we are talking about. This is a steam boiler. It doesn't make any difference what the fuel is, coal, gas, oil, or what have you. That steam is used in a power generator which generates power. That power drives a compressor, a steam compressor. The exhaust from this power unit comes down this way. The discharge from the power compressor is joined to it, and, just conventionally, we have shown a steam coil in the vessel, which is the evaporator. That steam is condensed in boiling water, the vapor goes off here, part of it goes back to be recompressed, and part of it goes on to be used in the succeeding vats. This is what we call a thermal compressor, where we take the vapor off an evaporator and compress it to the point where it is hot enough to be used for heating. It just goes round and round.

The most economical setup is one where that is combined with the exhaust from here running what we call a multiple evaporator. That is highly diagrammatic. The feed water comes in through a series of preheaters which are heated by the hot discharge and the hot—the cycle is within what is well known and has been used widely in many parts of the world.

The next slide. One thing that I am trying to do here is to show the design of an evaporator that I am proposing to you. Unfortu-

23642—58——6

nately, too much of this field has been dominated in the past by naval engineers, which has to be gotten between decks on shipboard. This is an evaporator well known and widely used, and has been for a long time.

Senator ANDERSON. We will have to take a recess at this time for a rollcall.

(A short recess was taken.)

Senator ANDERSON. Doctor, you may proceed.

Mr. BADGER. This evaporator is the type I propose to use. It is well known. There is a sheet here and one here, and tubes, approximately 20 feet long. The steam comes in here and surrounds the tubes on the outside.

Senator ANDERSON. Doctor, it is visible to us but won't be visible when reading it. Will you start back again?

Mr. BADGER. The tubes extend from the bottom to the top, about 20 feet long, each tube. The steam enters the top and surrounds the tubes on the outside. As it condenses the condensate is drawn off at the bottom point. The liquid to be evaporated is fed in at the bottom and goes up through the tubes, boils as it goes up, somewhere in the tubes, and issues from the tops of the tubes as a mixture of liquid spray and vapor.

The reason why I am advocating this type of evaporator is that it is the cheapest evaporator to build of all the types we know. It has one disadvantage: It does not behave well on solutions that deposit scale and, therefore, our problem has been to prove that this evaporator could run without scale.

Here is a steam boiler. It raises steam at about 600 to 800 pounds. That steam is used to drive two turbines. The first turbine drives an electric generator which supplies power for the pumps. The next one drives a steam compressor, which takes steam off the top of the evaporators, compresses it, and starts it back into them again.

There is, as I showed in the last section, more steam by using the exhaust from these turbines than this compressor can compress. The leftover steam is used to run a multiple-effective evaporator which is, of course, a design that is well known except that we have used more effects than customary.

The liquid, the raw sea water, comes in at the bottom, passes through a couple of heat exchangers to warm up and then is fed to the evaporators. In turn it is fed to more heat exchangers and so on up the line, winding up finally in the thermal effects. The discard liquor, because we don't evaporate all the water, only about 70 percent of it, the discard liquor comes down and runs through some of the heat interchangers, giving up its heat to the incoming feed.

The condensate from all the evaporators, which is the product of the cycle, comes down here and runs through the other set of heat exchangers, giving up its heat to the feed. So that the result is that you have sea water coming in at one end, you have cool discard brine coming out, and distilled water, the product of the cycle, coming out here. The difference between this cycle that I am talking about here and others that have been proposed is merely more refinement and more detail.

There is nothing new or nothing magic. All of the units involved here are things that you can go out and buy in America today.

This slide is a variant on that, which we feel has possibilities. A steam boiler, generating fairly high-pressure steam, which is used to operate a turbine, which turbine drives an electric generator, and that generates juice for sale. The exhaust from this turbine goes through a series of multiple-effective evaporators exactly like the last ones. There is now no thermal compression system in here. Whereas the previous plant produced water only, this plant produces for sale distilled water and electric power. So that this is hung onto it. You can think of it as this system being hung onto the tail end of an electric standard power system, except that where a standard electric power system exhausts from the turbine at the lowest possible vacuum, we exhaust at 10 to 15 pounds. We don't get quite as much power out of a pound of steam as a standard cycle does, but, on the other hand, we have an exhaust steam that is hot enough to run the evaporator.

Senator ANDERSON. Doctor, on the previous slide you showed, you said that all the parts were standard parts that you can buy on the American market?

Mr. BADGER. Yes, sir.

Senator ANDERSON. Have you ever built such a plant using these parts? Is there a plant like the one that you showed us?

Mr. BADGER. Not in some details. Let's see the next slide.

Here is a plant of these evaporators. There are scores and scores of them in the United States. This particular plant is concentrating the waste liquor from a sulfate pulp mill in Louisiana. This has eight effects, and the size of these effects is a little smaller than I would use for the largest plants I am prepared to suggest. These are definitely larger than the units that would be needed in a million-and-a-half-gallon plant.

Senator ANDERSON. If you were to build on of these million-gallon plants, would some of the cost be borne by the electricity that is generated?

Mr. BADGER. There are two separate cycles. One is the cycle which produces water only and no power for sale. The other cycle is one which produces both water and power for sale. The self-contained water plant, without selling any power, has certain advantages in that you don't need to be tied up with a power system. The other plant, however, has the advantage of credit from the sale of juice.

Senator ANDERSON. So it becomes more economical?

Mr. BADGER. It becomes more economical.

This is another slide. This evaporator has never been run on solutions that build scale, so we built this facility at Harbor Island—rather the Department of the Interior built it for us at Harbor Island. This is where I tested it out. You can compare that with the one I previously showed you. These units are merely units for preparing the feed to the evaporator.

The reports which we made to the Department of the Interior in 1955 indicated that the self-contained plant which produced no juice would produce water for about 32 cents a thousand gallons. That will have to be upped today somewhat due to the higher price of fuel and the higher price of equipment, but not a great deal; probably not over 40 cents.

Second, the plant which produces both power and water will have a balance sheet which depends on the price that can be obtained for the power. If power can be sold on the bus bar of the plant for 4 mills, water will cost about 27 or 28 cents a thousand gallons.

Senator ANDERSON. What would 5 mills make it?

Mr. BADGER. I will go one step further. If you can sell the power for 7 mills you will get your water for free.

There are a lot of economics tied up with all of it. I have sent you, Mr. Chairman, a letter outlining my views which can go into the record. I merely want to say that at the present time I am advocating a plant to produce about a million gallons a day, and I will explain why. The results at Harbor Island have been very encouraging. We have to prevent scale in these evaporators, and there are two ways that we can do it. One is by controlled feeding of acids. That method is known and is currently used in one modification or another by the Navy.

We believe that in a land-based large plant of this sort we can use cheaper methods than the Navy is forced to do.

Our experiments at Harbor Island have shown that that will be entirely successful, that it will absolutely prevent scale in all the bodies.

Senator ANDERSON. Do I understand from that that you do feel that it would be reasonable to go ahead and construct a million-gallon plant now?

Mr. BADGER. I do.

Senator ANDERSON. I do, too.

Mr. BADGER. There is a second method of preventing scale which comes out of many years of experience in the salt industry. Calcium sulfate is the worst scale former we have, and every salt plant in the United States evaporates a brine that is saturated with calcium sulfate. We always had to drill those things out once a week. There are sale evaporators in operation today that have been in operation for 7 years and have never had a tool in them. They are just as clean as the day they were put in them. That was due to a process that I and some of my colleagues developed, and it amounts to simply feeding a lot of calcium sulfate to the evaporator in the form of a slurry, because if that slurry is kept in suspension, when a molecule of calcium sulfate gets ready to sit down it would very much prefer to sit down on another crystal than calcium sulfate.

That is completely and practically successful and is in use in practically every large salt plant in the United States now, and has been for years.

The fact that it is successful with calcium sulfate does not per se guarantee it will be successful with calcium carbonate. We have to prove it. That work is at present underway at Harbor Island and before very many months have elapsed we will know whether that works or not.

Now I will back up and start another line of argument. In order to hold costs down——

Senator ANDERSON. Excuse me. Your letter of March 17 that you referred to will be put in the record at this point.

(The above-mentioned letter is as follows:)

LETTER FROM W. L. BADGER AND ASSOCIATES, INC.

W. L. BADGER AND ASSOCIATES, INC.,
Ann Arbor, Mich., March 17, 1958.

HON CLINTON P. ANDERSON,
Senate Subcommittee on Irrigation and Reclamation,
Senate Office Building, Washington, D. C.

DEAR SIR: This is in reply to your letter of February 28 requesting comments on Senate Joint Resolution 135. I am sending you, as requested, 25 copies of this letter; and I expect to be present at the hearings on March 20–21 in Washington.

I am not clear as to what you have in mind. In the Senate resolution you speak of "a full-scale demonstration plant." In your news release you speak of 3 approaches to the problem, which may mean 3 separate plants. I am going to discuss the matter on the latter basis.

1. I most emphatically urge that a plant be built to demonstrate the multiple-effect evaporator project for which I have been largely responsible. This seems to be the most promising avenue of approach at the present time. It does not require the development of new types of equipment, but depends for its success on the use of a type of evaporator well known and widely usd for many years, and on the use of extensions and elaboration of principles of design also already known.

The type of evaporator we propose to use is the long-tube vertical evaporator. It has been built in sizes greater than the requirements of a plant to produce 1 million gallons of fresh water per day from sea water. It has not yet been built commercially in as complex an arrangement as we propose, but this complexity offers little or no difficulty.

This type of evaporator has not yet been used on solutions that deposit scale, as does sea water. Our work on the pilot plant at Harbor Island, N. C., sponsored by the Department of the Interior, has so far given most encouraging results. It has shown that this evaporator can operate on sea water without scale formation by a controlled use of acid dosage, but low enough acidities so that corrosion in most of the evaporator will not be a problem. An even more desirable method of preventing scale is now being worked on, with present indications of a successful result.

2. Although in our reports to the Department of the Interior our calculations (and our most favorable cost results) were based on a plant to produce 15 to 20 million gallons per day, I suggest that a plant to produce about 1 million gallons fresh water per day be considered. This plant is to be looked on, not simply as a demonstration plant, but also as a plant for further studies.

In trying to keep the cost down, we have proposed that the plant be built of ordinary low-carbon steel. We have sound technical reasons for believing that this will be practical, but its practicability should be proven by about a year's experience in a plant of the size above-mentioned. Building a plant to produce 15 to 20 million gallons a day would greatly increase the cost of repairs or alterations if they should become necessary.

The step from the pilot plant at Harbor Island to a 1 million gallons per day plant is a large one, but not outside the reasonable risks of any engineering project of this magnitude. It would, however, represent much sounder engineering not to go at once to a 15 to 20 million gallons per day plant at this time. After we have had 6 months to a year of experience in the million-gallon plant, the step to 15 to 20 million gallons per day would not be excessive.

A plant to produce a million gallons per day could be shop-fabricated and assembled. A plant for larger capacities would have to be field-assembled.

3. The sole disadvantage of the plant to produce a million gallons per day is that it could not demonstrate the low costs we have predicated for the 17 million gallon plant. This is because both first costs increase, and efficiencies decrease, per unit of capacity, in the smaller sizes. The million gallon plant, however, would develop accurate data for predicting the costs that could be reached in a larger plant.

4. The recommendation that a million-gallon plant be built now, for further research and testing, does not mean that a larger plant must wait on the results of such an experimental program. The work necessary to design a plant to produce 15 to 20 million gallons a day is so great that many features (that do not depend on the results of the million-gallon plant) can be started at once.

As fast as results come out of the million-gallon plant, they can be incorporated at once in the calculations for the larger plant, thus much time can be saved in the design of the larger plant.

5. Our reports to the Department of the Interior have covered two cycles: (*a*) A plant using a combination of multiple-effect and thermocompression bodies, to produce only water; and (*b*) a plant consisting of a powerplant exhausting at modest back pressures to operate a multiple-effect evaporation. Such a plant would sell both power and water.

Plant (*b*) has many advantages and is probably (according to our present views) the more important development. However, for the million-gallon plant we are recommending, we recommend plant (*a*). This is because the million-gallon plant is still an experimental plant. If power is to be sold, the purchaser cannot tolerate the fluctuations in output that would be caused by many contingencies that might arise in experimental operation. Plant (*b*) is the simplest to build and to operate, so that when plant (*a*) has demonstrated its ability to perform, the engineering of plant (*b*) will follow logically and directly.

6. In the Virgin Islands 1 or 2 separate million-gallon plants will probably suffice. It would be vastly easier and cheaper to service a plant in continental United States than in the Virgin Islands. Once the million-gallon experimental plant has proved that it is sound and dependable, it can be copied for the Virgin Islands.

7. I am not sufficiently informed about the ionic-membrane processes to express any opinion about them, for or against.

Very truly yours,

W. L. BADGER.

Mr. BADGER. In order to hold costs down I have assumed this equipment can be built of ordinary carbon steel—black-sheet iron. We have quite a bit of information to the effect that that is possible. The naval evaporators in the past have always been built of special nonferrous alloys which are expensive, and that is because when you put a plant on shipboard you can't run any chance of the necessity for repairs.

Senator ANDERSON. It is a wholly different situation.

Mr. BADGER. It is. In a fixed, land-based plant you can allow a certain percentage of down time for repairs, if you have to.

I know that acid control will work. I believe that the sludge method of scale control will work, but that is yet to be proven. If I should have to design a plant now—and incidentally if the money were available I could start the engineering tomorrow—not tomorrow, because my vacation isn't finished, but when I get back from my vacation.

Senator ANDERSON. Next week.

Mr. BADGER. Yes, sir; next week.

Senator ANDERSON. What size would you build?

Mr. BADGER. About a million gallons.

Senator ANDERSON. Have you any idea how much it would cost?

Mr. BADGER. Yes, Again I must remind you that these estimates were made in 1955 and are somewhat low, probably.

Senator ANDERSON. Our recent bids on large irrigation dams have been down, rather than up.

Mr. BADGER. In the case of operating costs, it depends upon whether the figure that was established by the Department of the Interior in 1955 is still valid. But in 1955 this million gallons—actually, we calculated a plant for about a million and a quarter gallons a day, because it fitted a commercial-size turbine—cost about $1,200,000. That includes site development, office, shop, weatherproofing, engineering, and so on.

Senator ANDERSON. We had several million dollars in this bill. Would that leave you some money for operating costs and the like?

Mr. BADGER. Yes.

Senator ANDERSON. How much? Have you any idea what operating costs would be? I don't want to confine you to a dollar.

Mr. BADGER. I have it right here. In the operation of this million-and-a-quarter plant this estimate, made in 1955, shows a total annual operating cost—total annual cost, including interest, depreciation, insurance, maintenance, labor, and fuel—of about $325,000 a year.

This plant is one that I say I could start the design of tomorrow. There is enough work to be done so that before the design were finalized enough results from Harbor Island would be in so that I would know whether I had to use acid or not.

Senator ANDERSON. This bill gives the Secretary of the Interior 6 months to decide on the particular plant. He wouldn't need that much on the basis of present Harbor Island results.

Mr. BADGER. The way Harbor Island is going now I would hope to have those results in much less than 6 months. Let me make it plain: I can prevent scale by controlled-acid treatment.

Senator ANDERSON. You would rather try the slurry?

Mr. BADGER. I would rather try the slurry, because if I built my plant of carbon steel, I may have to go to acidities, and a couple of the effects are questionable for black iron. So they might have to be made from more expensive alloys, which would, however, increase the cost of water only a couple of cents a thousand gallons.

Really, before such a plant were built on a large scale, about 6 months' experience should be had in this million-gallon plant just to check such things as corrosion, which is a factor that you can't check with any short-term test. You simply have to put it up and live with it.

Senator ANDERSON. That is a very important statement. You simply have to put it up and live with it?

Mr. BADGER. Yes, sir.

Senator ANDERSON. That is why as many of us have been urging that the plant be put up so we would have a chance to live with it.

Mr. BADGER. Until the plant was built at Harbor Island, we weren't sure of what we wanted to build. Now we do. Harbor Island has been working 24 hours a day, 7 days a week, ever since it was started. I have a crew there to keep it going 24 hours a day except for periods of repairs and alterations.

This million-gallon-a-day plant which I would like to see built will do two things. It will give us a tool that we need for developing further refinements in the process. It is going to be—we know pretty well what it is going to do but there are always things you can do better after you have had a chance to work on them.

Second, it will demonstrate on an appreciable scale the practicability of this process. There is one thing it will not do: It will not confirm the costs that I have quoted to you because the cost of water per thousand gallons goes up very rapidly as the size of the plant decreases. That is because smaller equipment costs more per unit than big. It is also because the labor staff, the operating staff necessary to run a big evaporator, is no more men than are necessary to run a small evaporator.

Senator ANDERSON. About what size would it be if you tried to get down to the price that you indicated, say 30 cents a thousand gallons?

Mr. BADGER. That was figured on a 17 million gallon plant.

Senator ANDERSON. Which is not out of proportion at all to a great many of our American cities; is it?

Mr. BADGER. No. As a matter of fact, it would be only a fraction of the consumption of a great many of the American cities.

The reason we stopped at 17 million gallons a day was that was the largest size plant in which we could buy the necessary units commercially. As soon as you go above that size they become special, the cost of design rockets, and the first cost will be more than twice as much relatively, and therefore, if, for instance, a plant for 30,000 gallons a day is needed, I would build two 50,000-gallon plants and it wouldn't cost appreciably more. It wouldn't cost as much per unit of water manufacture.

Senator ANDERSON. You apparently have had a good deal of experience with this, because the experience of the Shippingport plant as against the *Nautilus* submarine bears out what you have stated.

As long as they could stay with stock sizes and patterns, the costs were relatively well known. When they had to develop a wholly new type, larger than the market had, the costs went up.

Mr. BADGER. I have seen that many times. Let me emphasize, there is nothing new or magic or different about the flowsheets that I am proposing. They are flowsheets that are well known. We are simply trying to make them a little more elaborate and use a little more engineering on them than has been considered in the past.

Senator ANDERSON. Senator Case, Dr. Badger mentioned the construction of a million-gallon plant to start, and that it could be built for something in the neighborhood of a million and a quarter dollars, without carefully checking his figures, in the hope that they would demonstrate the soundness of a larger plant that would produce this water somewhere around 30 cents or as low as 27 cents, if you could sell current for 4 mills in that type approach.

Senator CASE. Mr. Chairman, I was detained on the floor. I appreciate your going ahead with the hearing.

May I ask, what process would you use? I didn't catch that. I wasn't here in time to catch that.

Mr. BADGER. I was talking about ordinary multiple-effect evaporation, of a type that is well known and has been known for a hundred years.

Senator ANDERSON. Which he is now testing at Harbor Island.

Mr. BADGER. Yes. I am using a type of evaporator known as the long-tube vertical, which has been very widely used, but which is ordinarily considered to be unsuited for solutions that deposit scale. Therefore, we had to build Harbor Island to prove we could run this on sea water without forming scale.

I had two methods that I could have used to prevent scale. One is controlled-acid injection. That has been checked at Harbor Island and proved completely successful. We can absolutely prevent scale, the slightest trace of scale, by controlled-acid injection. I would rather not use that. I can. It is perfectly feasible.

The other method is a recirculation of slurry, which is paralleling a development we had in the salt industry which has been most successful. Harbor Island is just getting started on that cycle.

A million-gallons-a-day plant will not confirm the low prices that I have quoted for the 17-million-gallon plant. The million-gallon-a-day plant may cost somewhere in the neighborhood of 60, 70, or 80

cents a thousand gallons, but that is because of the increased cost of equipment in smaller units. However, it will give us the engineering data we need to project accurately the costs we can expect in the larger plants.

I would rather see a million-gallons-a-day plant go in for the reason that a million gallons a day is a plant big enough to involve all the engineering details that we have to be thrashed out. It is not so large that if anything goes haywire it won't be too expensive to make repairs. For instance, if I guess wrong and have to retube the evaporator, it won't be so expensive as it would be on a 17-million-gallon plant.

If there were an emergency, as with certain plants I built during wartime, where we had to take long chances, I would be willing to stick my neck out and design a 17-million-gallon plant, but there would be lots of questions there. There might be things happen.

It must be understood, however, that when I advocate a million-gallon plant, I want it distinctly understood that a million-gallon plant will not show any costs around 30 cents.

Senator ANDERSON. You have made that point.

Mr. BADGER. It will show that the process works. It will show that you can do this stuff with equipment that is now on the market. I don't have to develop any new types of equipment. I don't have to say any magic words over it or anything else. It is all relatively old stuff, merely a little bit more highly refined than we ordinarily considered necessary.

But I would like to see the million-gallon plant go in.

That million-gallon plant, the design of that million-gallon plant, could be started immediately if funds were available. Before the design is finalized the results of Harbor Island should come in. My guess is that that engineering can possibly be completed in somewhere between 6 and 9 months, and with present delivery on equipment of this sort, it is running about 9 months. So it will take about a year and a half if we could start right now, to have that million-gallon-a-day plant in operation.

One thing more. You will remember that I spoke of two cycles. One is a plant which generates water only, and nothing else. The second is a plant which generates both water and power. That second one apparently has the better possibilities for the future. I think more plants of that type will be built than of the straight water alone.

On the other hand, I would prefer to see this million-gallon plant built on the first scheme—that is, producing water only—for the sole reason that the minute I begin to talk about a return from power sales, then I get all tangled up in the demand requirements of the company that receives the power. Anybody who buys power from such an installation as this can't tolerate the shutdowns that might be necessary to make alterations as developed by experimental work.

Senator ANDERSON. Yes, and you would get mixed up in the argument over public versus private power, preference clauses, and what has to be sold to the REA before the local utility can buy it.

Mr. BADGER. It is complicated.

Senator ANDERSON. It is far away.

Mr. BADGER. The plant to produce water only, and not water and power, will be a little more expensive than the figures I quoted for such a plant, and it will be a little more complicated. But when you think

of the complications that have come from the attempts in selling power, I think the wise thing to do would be to forget the power at present.

So far as the 17-million-gallon-a-day plant is concerned, which in the present is about the maximum that really could be started almost any time on the engineering.

Senator ANDERSON. I saw on this list a representative of the Badger Co. Are you connected with that company?

Mr. BADGER. In Boston there used to be a firm, E. B. Badger & Sons Co., of which the present Badger Engineering Co. is the successor. The two family lines are entirely separate. I have never had any connection with the Boston outfit. If you go back to 1700, the 2 families were together, but not since then.

Senator ANDERSON. Thank you. If it is possible, we would like to have more detailed costs, which you can file subsequently for the record.

Mr. BADGER. We have not yet revised the costs that we produced for the Department of the Interior in 1955.

Senator ANDERSON. Just anything that you have for the record.

Mr. BADGER. All right.

(Mr. Badger subsequently submitted the following information:)

Capital cost of 1.28-million-gallons-per-day-plant (1955)

Boiler	[1] $160,000
Turbine generator	[1] 43,000
Turbine compressor	[1] 132,000
Evaporators	[1] 272,000
Heat exchangers	[1] 97,000
Pumps	[1] 47,000
Piping	[1] 90,000
Instruments	[1] 32,000
Total process equipment	873,000
Site development	20,000
Office, shop, lab	80,000
Weatherproofing	44,000
Engineering	70,000
Contingencies	87,000
Total	1,174,000

[1] Installed.

Or $858 per annual acre-foot.

Capital cost of 17.35-million-gallons-per-day plant (1955)

Boiler	[1] $1,020,000
Turbine generator	[1] 170,000
Turbine compressor	[1] 925,000
Evaporators	[1] 2,425,000
Heat exchangers	[1] 991,000
Pumps	[1] 138,000
Piping	[1] 305,000
Instruments	[1] 40,000
Total process equipment	6,014,000
Site development	70,000
Office, shop, and lab	135,000
Weatherproofing	300,000
Engineering	481,000
Contingencies	600,000
Total	7,600,000

[1] Installed.

Or $407.50 per annual acre-foot.

Senator ANDERSON. The next witnesses are Mr. E. R. Gilliland, of the Massachusetts Institute of Technology, and Dr. Walter Juda, Ionics, Inc., Cambridge, Mass.

Will you state your names for the record, please?

Mr. GILLILAND. My name is Edward R. Gilliland, and I am president of Ionics, Inc.

Mr. JUDA. I am Walter Juda, executive vice president of Ionics.

STATEMENTS OF E. R. GILLILAND, PRESIDENT, AND DR. WALTER JUDA, EXECUTIVE VICE PRESIDENT, IONICS, INC., CAMBRIDGE, MASS.

Mr. GILLILAND. Mr. Chairman, I would like to go over our brief statement here and then try to answer any questions you may have relative to the Ionics process. First, we wish to express our appreciation to you and the committee for inviting us to appear here today and testify on the resolution.

We believe that this resolution at this time is a most important event in furthering the development of saline water conversion processes and the utilization of important new sources of water. To put it another way: The desert will never bloom, until someone puts water on it.

We are impressed by your foresight, your appreciation of the enormity of the problem and the need for action now.

I would like to limit my remarks to a short review of our position and recommendations. There is supplemental material here that we can go into if you desire which gives more detailed information on the operation of the Ionics equipment.

Ionics, Inc., was founded in 1948 to develop and exploit a new technology in ion exchange for demineralizing saline water and other purposes. Walter Juda and his collaborator, Wayne A. McRae, developed the totally new technique by making membrances of selective ion exchange resins and incorporating these membranes into a unit which removes dissolved salts from water. United States and foreign governments have recognized this original work and subsequent improvements by issuing patents.

Since that time Ionics has built and sold 24 units ranging in size from 300 up to 86,000 gallons per day. Some of these units have operated around the clock throughout the year at an average of 95 percent of the time and have been in operation for as long as 2½ years providing potable water to some 35,000 people. These people tell us they like the water from an Ionics unit because it has a normal fresh-water taste. I believe some of your members have tasted water from Ionics' units. These units, many of which are overseas, have been operated and maintained successfully by unskilled operators after a period of training. Others of special designs are operating as research and test units for specific military and commercial applications operating on both sea water and brackish. A list of these units appears in my supplementary statement, the capacities and type of water they operate on, what type of water they produce, the number of operating hours, and so forth. We can look at them briefly now or later.

Senator ANDERSON. Later.

Mr. GILLILAND. From this manufacturing and operating experience, we can report that Ionics membranes have an average life of at least 3 years, that when operating on brackish water within the 1,500 to 4,000 parts per minute range—this is parts of salt—electrical consumption is 25 kilowatt-hours or less per 1,000 gallons.

This, then, briefly describes Ionics' product and credentials which we believe uniquely qualifies it as a supplier of a "full-scale demonstration plant for the production of water suitable for agriculture, industrial, municipal, and other beneficial consumptive uses." This is a quote from the preamble of Senate Joint Resolution 135.

We were pleased to note, Mr. Chairman, in your press release of February 28 that these hearings would endeavor to bring into focus information on three important areas: California seacoast with its abundantly available sea water, inland areas both in the United States and overseas beyond the economic reach of pipelines or aquaducts where brackish water is abundantly available, and the Virgin Islands with its special water and power problem. We agree that these are three areas of the water problem. We particularly concur with the view that vast areas of the United States, Middle West, Southwest, and Rocky Mountain regions, as well as isolated areas east of the Mississippi have urgent need for water which can be satisfied by conversion of indigenous supplies of brackish water.

Transportation of water by pipeline is expensive. We believe, therefore, that conversion of indigenous brackish water supplies at the site of consumption can be a more economical operation. Even with a zero cost for conversion of sea water, it appears improbable that it can be economically transported by pipeline more than a few hundred miles.

We know also from firsthand knowledge that abundant brackish water exists in much of Australia, Hawaiian Islands, Pakistan, Africa, the Middle East, and South America. Walter Juda, who is with me today, and his associates have personally surveyed these areas within the past 2 years.

The problem which this legislation if enacted poses to the Secretary of Interior is: What processes should be selected and where shall these plants be located? The most attractive process for conversion of saline water depends upon whether the feed water is brackish or sea water.

The Ionics' membrane system has demonstrated the lowest cost to date of any system for converting brackish waters. Any one of several thermal systems, or even a freezing system, may prove to be the lowest cost method for sea water conversion.

But here I would like to point out that a great many of the locations on the seacoast also have large supplies of brackish water, and it may be cheaper to convert brackish water in those locations than it is to demineralize sea water.

Likewise, as the table indicates, Ionics' units do operate on sea water. We have a number of them operating on sea water. We are very hopeful, that with improvements, on sea water we can make the membrane units competitive with many of the other types of equipment.

As compared to Professor Badger's comments of evaporators as being old, membrane units are new, and we foresee a large improvement down through the years in reductions of cost still to come.

The fact that electrodialysis is a commercial reality is confirmed by Secretary of Interior Seaton in his February 22, 1958, press release. If this statement refers to Ionics' equipment—and we are unaware of any other electrodialysis equipment operating commercially—these are quite small in size in comparison to those envisioned in this resolution.

As mentioned before, 86,000 gallons per day is the largest of any units we have out in operation. Construction and operation of plants of the size proposed are essential to demonstrate the lowest inherent costs and operating problems of each system.

We of Ionics like to think that electrodialysis has been brought into commercial reality in the finest tradition of American free enterprise. Its rewards are its successful system, its patents, and its potential markets; its satisfaction is in the knowledge that this equipment can help substantially to fill an urgent need for abundant water for millions of people throughout the world.

We would at this point acknowledge the assistance given us by the Office of Saline Water in the early days of its eixstence. If my memory serves me right, our first contract was issued by the Department of Interior before the Office of Saline Water was officially organized. Some $190,000 of the Office's funds were expended in furthering development work on the basic Ionics' unit and culminated in the construction and delivery of the first portable, trailer-mounted unit to the Office of Saline Water 2 years ago for tests. Along with this help, Ionics' stockholders and customers made available another $1¾ million for the development of membranes and membrane equipment, which brings the total to roughly $2 million.

It would be difficult at the present time, Mr. Chairman, to tell you precisely what a full-scale demonstration plant using Ionics' equipment would cost. We would need to know where the plant was to be built, what the power cost was at the site, the average salinity of the feed water, and all the usual variables such as labor rates, interest charges, rate of amortization, taxes, and so forth.

A general estimate can be derived from over 5 years experience building small plants and observing their operation. We would offer the following figures to be our estimate of the cost. If given a domestic order today for our current production equipment, the kind we are selling today in small units, we believe that we could supply a several million gallons per day plant producing water of 500 parts per million from feed water of 2,400 parts per million for a capital cost of $1.15 to $1.30 per gallon per day of capacity, complete including building.

For a million-gallon-per-day plant you would multiply this number by a million to arrive at the plant's capital investment. Somewhat between $1,150,000 and $1,300,000 for a million gallons per day plant.

The operating cost would be about 65 cents per thousand gallons including amortization, direct labor, membrane replacement, and power—and this is electrical power at 10 mills per kilowatt-hour. There is a breakdown of the operating cost in one of the documents in the supplement. This plant would include the building and site.

Senator ANDERSON. What would happen if you located the plant in an area where they had power at 5 mills per kilowatt-hour?

Mr. GILLILAND. In the table at the back of the supplemental material, case I, our present equipment, the power is 7.2 cents. By going down to 5 mills you would knock off 3½ cents from the water.

In these small plants, amortization is high.

We believe considerable improvements can be made in the process, and we have been spending our own money all the time trying to do this, and we have some new developments under way now that we estimate we could deliver the same size plant as mentioned above for a capital cost of 70 to 80 cents per installed gallon of daily capacity, with an estimated operating cost of about 35 cents per thousand gallons, using the same feed water and the same power costs as mentioned above.

The difference would be, in the one above we have had considerable operating experience in small units, and we think we know the answers to a lot of the problems. Every time you redesign units, there will be more. There is no doubt about this.

Senator ANDERSON. You can generate current in large capacities in California easily for 5 mills, and in many areas there the rates are below that. The Bonneville district, for example. So, if you knocked off another 3½ cents, you would bring this down pretty close to the 30-cent figure that we have had before.

Mr. GILLILAND. It is closer than that. If you notice case II in my supplemental statement, this redesign is the design to use more power and reduce original investment.

Senator ANDERSON. It would take off 4⅓?

Mr. GILLILAND. Yes, sir. In the event such a plant was ordered from Ionics, we would plan to furnish the equipment and do the installation, and work with one of the large engineering and construction companies to do the building and provide a turnkey job.

We do not delude ourselves in believing that this projection is competitive with free running water for irrigation. We do know that the need exists, and this price is attractive in many areas. Like all estimates, these figures cannot be realized until demonstrated.

In other words, the cost on our 86,000-gallon-a-day plants are higher than this. We likewise expect that if we build plants above ten million gallons per day they will go down still further in cost.

This is the service to the people of the United States and the free world that Senate Joint Resolution 135 can provide. We point out, however, that our estimates are based upon more actual experience than that which the South African group had when they started construction of their 3-million-a-day plant. They went ahead on very little. They were going to take the chance and see what happened. In fact, there were some questions. We had the paper they presented at the Department of the Interior meeting last fall. They actually called their plant an experimental plant. It was 2.4 million imperial gallons a day, the official rating.

In conclusion, Mr. Chairman, we are in favor of the intent of the legislation before this committee. Specifically, we emphatically agree that the saline water problem is twofold, sea-water conversion and brackish-water conversion, and we are in favor of legislation that brings about the prompt construction and operation of such demonstration equipment.

I want to thank you and the committee for this opportunity to appear and certainly assure you of the cooperation of Ionics on anything that is to be done. Dr. Juda is here with us today, and he would be very glad to answer any questions that you have on technical problems or problems in foreign areas of the world with most of our equipment.

(The supplemental statement is as follows:)

SUPPLEMENTAL STATEMENT OF E. R. GILLILAND, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

BRIEF SUMMARY OF BRACKISH WATER RESOURCES

The Geological Survey, water supply paper No. 1374 entitled "Preliminary Survey of the Saline Water Resources of the United States" has two very revealing maps tucked into a pocket inside the back cover.

A glance at these two maps reveals in a most graphic fashion the extent of and the wide distribution of surface and underground saline water.

It may come as a surprise that there are many areas and communities in the United States where the saline content of water being used for human consumption is much in excess of that set as a maximum by the United States Public Health Service.

For example, a 1946 Texas Board of Water Engineers publication entitled "Public Water Supplies in Southern Texas" reported that approximately three-eighths of the 138 public well-water supplies in that area had total dissolved solids in excess of 1,000 parts per million. (The maximum deemed suitable by the United States Public Health Service.) While most of the highly mineralized supplies occur in small towns, the rapidly growing west Texas city of Midland (population now estimated at well over 50,000 people) used well-water supplies varying from 800 to 2,200 parts per million in 1953.

North and South Dakota have ground water supplies available in quantity which are highly mineralized, and a number of cities, including Grafton and Devil's Lake, make use of these highly mineralized waters for public supply. Mr. Charles E. Carl, director, division of sanitary engineering, State department of health, Pierre, S. Dak., had the following to say in a paper delivered last year: "Many geologic formations in South Dakota furnish hot waters (up to 130° F); high solids (up to 3,700 parts per million); high hardness (up to 1,800 parts per million); high sulfates (up to 1,400 parts per million); high chlorides (up to 1,500 parts per million); high fluorides (up to nearly 7 parts per million); and iron and manganese (up to nearly 8 parts per million). Some South Dakota well waters are wet but beyond that can hardly be called water as far as domestic consumption is concerned."

SERVICE LIFE OF IONICS MEMBRANES

Last November Dr. Walter Juda presented a paper at the saline water symposium sponsored by the office of saline water in which it was reported that the average life of an Ionics membrane was 3 years.

This figure was conservative in that it included significant numbers of membranes replaced for discoloration which had no effect on their efficiency, and old-type membranes manufactured 3 or 4 years ago.

Additional incomplete data received from Ionics units out in the field not only confirm the predicted 3-year life of the membranes but show a definite trend toward a longer average life.

One plant in the Middle East, for example, is approaching the end of 2 years of operation with a membrane replacement rate of 3 percent per year.

Within the past 2 years, a new reinforcing fabric has been incorporated in the Ionics membranes, which together with a simple and cheap technique devised to prevent scaling has significantly lengthened the service life of the membranes.

CURRENT DEVELOPMENTS UNDERWAY AT IONICS

Ionics is midway through a company-sponsored development program which promises to lower significantly both the capital cost of the equipment and its operating costs.

Briefly, this is a program which will increase the size of the present membrane, incorporate a new and much more efficient spacer, and permit the operation of the unit at significantly higher output.

Estimates of the reduction in costs are shown below in the column marked "Case II." Costs of present equipment are shown in the column marked "Case I."

Design basis:

Production rate, 2.8 million gallons per day
Influent concentration, 2,400 parts per million
Effluent concentration, 500 parts per million
Amortization period, 20 years at 3 percent sinking fund
Membrane replacement rate, one-third per year
Price of electricity, 1 cent per kilowatt hour

	Case I	Case II
Investment (plant installed at site)	$3,400,000	$2,000,000
Operating cost (cents per 1,000 gallons):		
Amortization	21.5	12.7
Membrane replacement	28.6	8.2
Power	7.2	8.7
Direct labor	5.7	3.5
Miscellaneous expenses	2.4	2.0
	65.4	35.1

PATENTS

A broad class of ion exchange membranes, including Ionics' Nepton membranes, the use of such membranes in electrical systems, and certain other features of the Ionics demineralizers are covered by the following United States and foreign patents, as well as other pending.

UNITED STATES

2,636,851	2,731,411	2,752,306
2,636,852	2,731,425	2,756,202
2,694,680	2,732,350	2,777,811
2,702,272	2,732,351	2,780,604
2,708,658	2,736,637	2,776,258
2,730,768	2,741,591	2,800,445
2,731,408	2,741,595	2,826,544

FOREIGN

Australia:	Cuba:	Italy:
158,405	14.845	481,401
161,042	15,529	504,848
165,858	France:	513,290
167,661	1,020,114	South Africa:
Belgium:	1,084,341	10,601
496,550	Great Britain:	Spain:
521,454	720,002	193,837
Canada:	India:	Switzerland:
504,146	43,336	305,105

Between 1948 and 1949, development work on the Ionics membranes had proceeded to the point where applications for patents on the membranes, use of membranes in an electrical system, and certain features of the Ionics demineralizing unit could be filed.

The patents which have issued both in the United States and overseas and others applied for gives Ionics a strong position in this field.

OVERSEAS ACTIVITY

Nearly 70 percent of the equipment sold to date by Ionics has been installed overseas, primarily in the Middle East and North Africa.

The interesting fact about this pattern of distribution is that more than 2 years ago, private companies both very large and very small recognized the value of this new technology, and were willing to invest their funds in a radically new type of equipment. The reasons they give are the efficiency, reliability, and ease of operation and maintenance. Virtually all of these overseas plants are being operated and maintained by nationals of the area after a short period of instruction.

23642—58——7

Plant No.	Operating organization and location	Date of startup	Source of water	Purpose of plant [1]	Total hours of operation [2]	TDS, feed	PPM Prod.	Production rate (gallons per hour)	Total energy consumption kwh/k gal.
1	([3])	October 1954	Well	P	12,000	2,000	500	200	15
				X					
2	Texas Electric Service Co., Wichita Falls, Tex	do		(P)	9,500	1,700	400	1,200	12
				X					
3	Department of Interior:								
	Buckeye, Ariz	January 1955	Well		740	4,000	400	1,000	20
	Miller, S. Dak	August 1955	do		540	2,000	700	1,700	10
	Denver, Colo	May 1956			1,000	2,000	700	1,700	10
4	Bahrain Petroleum Co., Bahrain	June 1955	Well	P	21,000	3,150	400	1,260	16
	Revised larger plant	September 1957	do		4,300	3,150	400	3,780	16
5	Bureau of Yards and Docks, California	September 1955		X	8,500	3,500	175	75	15
6	U. S. Air Force, Texas tower No. 2	November 1955	Sea	P	1,000	32,000	500	120	135
7	Bureau of Ships, Annapolis, Md	February 1956	do	X	5,000	32,000	200	15	160
8	Egyptian Army	June 1956	Well	P		1,000–8,000	500	100–800	5–35
9	Yateem Bros., Bahrain	do	do	P	13,000	3,100	200	200	15
10	U. S. Air Force, Havre, Mont	July 1956	do	P	11,000	1,800	500	700	8
11	U. S. Air Force, Holloman, N. Mex	do	do	X	200	Variable	Variable	100–800	Variable
12	Bureau of Yards and Docks, California	January 1957	Sea	X	1,400	32,000	200	100	135
13	U. S. Air Force, Texas tower No. 3	do	do	X	4,000	32,000	500	120	135
14	U. S. Air Force, Texas tower No. 4	December 1957	do	P	2,000	32,000	500	120	135
15	Kuwait Oil Co., Kuwait	June 1957	Well	P	3,600	5,000	500	180	25
16	Algosaibi Bros., Bahrain	May 1957	do	P	6,000	3,200	350	200	18
17	([3])	April 1958	do	P	0	1,800	280	1,200	14
18	New York Thruway Authority	do	do	P	0	2,540	410	500	15
19	Getty Oil Co., Kuwait	([4])	do	P	0	22,000	500	160	110
20	Egyptain Army	April 1958	do	P	0	1,000–8,000	500	100–800	5–35
21	CAA, Alaska	June 1958	do	P	0	5,000	600	125	25
22	do	do	Surface	P	0	1,500	600	50	12
23	Oasis Oil Co	March 1958	Well	P	0	3,400	500	30	22
24	([3])	April 1958	do	P	0	11,000	500	13	70

[1] X = Experimental; P = Production.
[2] Estimated to Mar. 15, 1957.
[3] Customers prefer nondisclosure.
[4] Pending.

Senator ANDERSON. Thank you very much. Senator Case?

Senator CASE. I would like for Mr. Gilliland or Dr. Juda to state for the record why they think the Ionic process is better for brackish waters than any other processes currently proposed.

Mr. GILLILAND. Largely on the basis of economics. Ionics processes, in removing the salt from the water instead of water from salt, becomes more advantageous as the salt concentration goes down, because our costs are somewhat proportional to how much salt you have to remove. The costs of others are proportionate to the amount of water you have to take out. So when you go to sea water there is a larger amount of salt to be taken out from the water. In ours, we have to take out a larger amount of salt per 1,000 gallons. In brackish water, to get the same amount of good water, you have to remove much lower amounts of salt. This makes the operation attractive in the brackish-water region.

Senator CASE. I noticed from your statement that you thought the membranes would last 3 years.

Mr. GILLILAND. We think they will last much more. The largest plant we have in the operation has been going for almost 3 years. Its demonstrated membrane life is considerably above 3 years. In fact, we have 1 plant that has been in operation 2 years. In that period they have replaced only 2 percent of the membranes per year. So, we feel that the average life of a membrane will be much longer than 3 years. But until you run them for a long period there is no way to guarantee this.

Mr. JUDA. I would like to make another point on your question of why we think membranes are better on brackish water than any other process. The scaling problem with brackish water is usually more severe than with sea water, because there are much higher quantities of calcium sulfate present. Actually, now, several evaporator companies will sell equipment for sea water and will be hesitant to sell it to operate on brackish water. The scaling problem is easier to control on brackish water with the membrane process than with the distillation equipment. So, there is a cost factor and also a technical factor which makes membranes more desirable in brackish water.

Senator CASE. Is there any quantity or capability factor which dictates the size of the units that you would build?

Mr. GILLILAND. Not the size of the plant but the size of the unit? We have these individual stacks.

Senator CASE. I understand. That was pointed out this morning.

Mr. GILLILAND. One of the improvements involved in this case II is to build larger stacks than we now build. On the other hand, I am sure, for a million-gallon-a-day plant, we do not contemplate building a single large stack. This will be a multiple-stack plant.

Senator CASE. You think the multiple stack offers more practical ways of increasing the capability in terms of size or amount of water produced than increase the size of the unit itself?

Mr. GILLILAND. We would like to do both, but there are some real engineering problems in increasing the size of the stacks. While I am sure that down through the years the stacks will become larger, at the present time we would build them with one-size stacks and put them in multiples for this plant.

Senator CASE. I suppose the replacement of some of the membranes would be more readily accomplished in a smaller stack than a larger?

Mr. JUDA. Plus the fact that if, in a multiple stack plant, one is out of order, the production rate goes down very little. If you had only 1 or 2 very large stacks and 1 is out of order, you would half the production rate. So there is an advantage in multiplicity which is also used in other industries.

Senator CASE. Have you worked on the plant which the Department of the Interior used in Arizona and South Dakota? Have you worked on it since it was used there?

Mr. JUDA. We have not worked on it since it was used there. We have made some changes in Denver. We have put some newer membranes in, delivered some newer membranes. I forget whether it was during the testing or after.

Senator CASE. Have you modified your stack design since then?

Mr. JUDA. Yes. First of all, we are using newer and better membranes. Secondly, we have made a series of simplifications from an engineering standpoint.

Senator CASE. Do you think they are more efficient than the older ones?

Mr. JUDA. Yes; they are more efficient than the older ones. However, the improvement program that we are talking about here is considerably bigger than just simple improvements on the present unit. Another point: these new improvements are simple concepts; they do not involve any really new or big thoughts. They are making things bigger and utilizing materials better.

Senator CASE. You say you sold 24 plants?

Mr. JUDA. Yes, sir.

Senator CASE. Who have been your customers?

Mr. JUDA. They are listed in our supplemental statement.

Mr. GILLILAND. They list the locations, startup date, source of water, and other operating characteristics. They are listed in chronological order as to when they were put into the field.

Senator CASE. Are you getting reports of the results accomplished? Do you follow them after you put them out?

Mr. JUDA. Yes. This takes a good deal of traveling, and that is why we get about a good deal.

Senator CASE. Is it planned to equip all of the Texas towers with one of your units?

Mr. JUDA. There are three Texas towers built or building, and they are all equipped, as far as I know. I understand there is one not actually using its Ionics unit.

Senator CASE. Is the Air Force planning to use them at other isolated installations?

Mr. JUDA. They are. We have two of them on that list. Numbers 10 and 11.

Senator CASE. Are the ones at Havre and Holloman dealing with brackish waters rather than sea water?

Mr. JUDA. Yes.

Senator CASE. And the Texas towers are dealing with sea water?

Mr. JUDA. Yes, sir.

Senator CASE. What others do you have on there that are using sea water?

Mr. GILLILAND. Numbers 6 and 7. The Bureau of Ships at Annapolis has an experimental unit.

Mr. JUDA. Twelve, at Port Hueneme, Bureau of Yards and Docks.

Senator CASE. I notice you have one at Kuwait, for the Getty Oil Co.?

Mr. JUDA. Yes, sir.

Senator CASE. Is that a salt-water problem?

Mr. JUDA. No. That is a very highly mineralized brackish water. It is 22,000 p. p. m. Sea water is 35,000 p. p. m.

Senator CASE. That is not in operation?

Mr. JUDA. It has been delivered but not started up.

Senator CASE. What is the place where you have one in the longest period of continuous operation?

Mr. JUDA. That is No. 4, with the Bahrein Petroleum Co., which has now 21,000 hours. It will have been in operation 3 years in June.

Senator CASE. Below that you have the "Revised larger plant." That was put in some 2 years after the first plant?

Mr. JUDA. That's right. That is an interesting thing. We did get a reorder from them, tripling the original plant within a few months, primarily because of the fact that the water tasted, for the first time there, so well that it really created a demand for it.

Senator CASE. I notice No. 9, another one in Bahrein, and also 16.

Mr. GILLILAND. These are private individuals.

Senator CASE. Did those orders grow out of the one that you first placed there?

Mr. JUDA. We believe so.

Senator CASE. In 1955?

Mr. GILLILAND. These are private individuals taking water, bottling it, and selling it.

Senator CASE. There is no better recommendation than a satisfied customer.

Do you have any cost figures on the basis of these that have been in operation some time that lend any special light upon your estimate of costs now?

Mr. GILLILAND. The last column gives the kilowatt-hours. These are the power consumptions. We have good information on what kind of power these units are using per thousand gallons of water, and we quoted 25. There are a number of plants operating lower than 25 kilowatt-hours per thousand gallons in operation. Sea water takes more power because of the higher salinity to be removed.

Senator CASE. I notice you have 1 plant there as small as 15 gallons per hour, 30, 50, and 13.

Mr. JUDA. Yes, sir.

Senator CASE. What are your costs when you get down to plants that handle 50 gallons per hour?

Mr. GILLILAND. Take 22, which has 30.

Mr. JUDA. This costs in the order of $8,000, this piece of equipment.

Senator CASE. Distributing that over the life of the plant, what would you get for a per-gallon cost of water per thousand gallons?

Mr. JUDA. It is very arbitrary, because sometimes they are in exploration camps where they just use it for 6 months or a year. This is very high-cost water, of course.

Senator CASE. That is very high cost?

Mr. JUDA. On that scale any system will give you high-cost water.

Mr. GILLILAND. It is only by getting up to a million-gallon-a-day region that you will get the cost down. In fact, this is one of the

problems. The small units have high cost and you have to find the limited users that can justify a very high cost. There is this difficulty, then, of jumping over and demonstrating the low cost on a large scale to interest the people who need the low-cost water. This is one of the reasons we feel that these plants of 1 million gallon capacity will be very helpful in taking this jump across.

Senator ANDERSON. You did some work in the Virgin Islands; didn't you?

Mr. GILLILAND. We have had people in the Virgin Islands. We have not had any units in the Virgin Islands.

Mr. JUDA. There is some evidence that there may be some brackish water on the Virgin Islands. The question is, is there enough? If there is, it might be cheaper to use the membrane process rather than sea water conversion.

Senator ANDERSON. Are you the people who pumped one well for a while and needed to pump another one and couldn't get permission from the Federal Housing Administration?

Mr. GILLILAND. No.

Senator ANDERSON. I am thinking of counterpart funds. We can't get two branches of our own Government to cooperate.

Thank you very much. It is a fine statement. We appreciate your being here. The best part of it is that it looks like you have had some experience. It looks encouraging.

Mr. GILLILAND. We would like to have more experience.

Thank you very much.

(The following information was subsequently received from Mr. Gilliland:)

SUPPLEMENTAL EXHIBIT OF EDWIN R. GILLILAND, PRESIDENT, IONICS, INC.

Typical of communities in the United States, which have local sources of water containing total dissolved solids in the range of 1,600 to 2,000 parts per million, are Miller, S. Dak.; Delmar, Calif.; and Midland, Tex.

The conversion of these available supplies of brackish water into potable drinking water would make available to these, and any similarly situated, communities additional good water to meet the needs of their expanding population and industries, and at the same time demonstrate the reliability, operating characteristics, and economic potentials of the electrodialysis conversion equipment.

For planning purposes, Ionics, Inc., has prepared cost estimates on three different size demineralizing plants, assuming that these plants could be integrated into the existing water distribution system of the towns.

It is obvious that a firm estimate of cost could only be made after a detailed site survey had been conducted and construction costs of the building, site preparation, and utility connections had been developed for each plant.

1. Miller, S. Dak.:

Water supply	parts per million	1,950
Product water	do	500
Proposed Ionics plant capacity (200,000 gallons per day):		
Building cost, site preparation, utility connections, on site engineering, installation cost, etc		$87,000
Membrane stacks, rectifiers, pumps, piping, controls, and all associated equipment delivered to the site		233,000
Total estimated cost		320,000
Estimated cost per daily gallon of output		$1.60
Estimated operating cost per 1,000 gallons of output	cents	58–65

2. Delmar, Calif.:	
Water supply—parts per million	1,670
Product water—do	500
Proposed Ionics plant capacity (500,000 gallons per day):	
Building cost, site preparation, utility connections, on site engineering, installation cost, etc	$150,000
Membrane stacks, rectifiers, pumps, piping, valves, controls, and associated equipment delivered to the site	550,000
Total estimated cost	700,000
Estimated cost per daily gallon of output	$1.40
Estimated operating cost per 1,000 gallons of output—cents	50–55
3. Midland, Tex.:	
Water supply—parts per million	1,910
Product water—do	500
Proposed Ionics plant capacity (1,000,000 gallons per day):	
Building cost, site preparation, utility connections, on site engineering, installation cost, etc	$275,000
Membrane stacks, rectifiers, pumps, piping, valves, controls, and associated equipment delivered to the site	975,000
Total estimated cost	1,250,000
Estimated cost per daily gallon of output	$1.25
Estimated operating cost per 1,000 gallons of output—cents	56–62

Senator ANDERSON. Mr. Gardner?

STATEMENT OF WILLIAM A. GARDNER, STAFF ENGINEER, GRISCOM-RUSSELL CO., MASSILLON, OHIO

Mr. GARDNER. Mr. Chairman and Senator Case, my name is William A. Gardner. I am staff engineer of the Griscom-Russell Co., of Massillon, Ohio.

We appreciate this opportunity of presenting our views on the legislation now under consideration by this committee. We were privileged to submit a statement in 1952 concerning legislation which led to the establishment of the Office of Saline Water as authorized by Public Law 448, 82d Congress.

In preparing the following information, we have reviewed our statement of 1952 and find that, in essence, our opinions are the same now as they were then. Briefly, we stated that distillation is the only method sufficiently well developed to provide large quantities of fresh water from sea water in the foreseeable future. We also stated that in our opinion low-pressure multiple-stage flash distilling plants associated with power-producing turbines would result in the lowest charges for fresh-water production, that design criteria have been developed to the point that further laboratory research is not required, and we recommend legislation which would permit the construction and operation of large-size pilot plants. It is recognized that other processes may show advantages in the treatment of brackish waters.

Significant progress has been made under the direction of the Office of Saline Water since the enactment of Public Law 448. Considerable basic research work has been accomplished, involving not only distillation but many other promising processes. A number of design contracts have been completed, including a contract with our company

involving research on and analysis of single-stage low-temperature flash evaporation processes. Experimental work is now being conducted on full-strength sea water at Wrightsville Beach, N. C., under the auspices of the Office of Saline Water, including the testing of a 25,000 gallons per day rotary vapor compression still and of long-tube vertical distillation equipment as described by Dr. Badger.

Quite apart from activities sponsored by the Office of Saline Water, many manufacturers have been proceeding on their own with basic research, pilot-plant experimentation, and the design and manufacture of production size units. This activity has contributed greatly to the knowledge of all of the known processes, particularly distillation. We believe that those who attended the International Symposium on Saline Water Conversion in Washington last November, sponsored by the Office of Saline Water, are in substantial agreement that distillation of sea water to produce fresh water still offers the most practical method for producing large quantities of fresh water at low cost. There are many parts of the world in which it has become necessary to provide large quantities of fresh water from sea water immediately, without awaiting a major breakthrough in fundamental research. As far as is known, in all these instances the solution has been distillation. Although it has been shown that electrodialysis schemes are practical for brackish water in which the concentration of total solids in the water does not exceed approximately 5,000 parts per million, the costs for power and maintenance become prohibitive when treating normal sea water which contains approximately 35,000 parts per million total solids.

Numerous distillation schemes are completely practical at the present time and are being employed in naval, Marine and land-based service. Therefore, it is not a case of determining whether those distillation cycles will work; it is well known that they do. Griscom-Russell has long felt the urgent need for lowering the costs of producing fresh water from sea water by distillation. At this stage, we feel the best method of accomplishing this end is flash distillation. Many manufacturers, including ourselves, tend to take a conservative approach in regard to design criteria and materials of construction. This is largely due to the fact that the bulk of past experience has been conditioned by requirements for furnishing equipment for naval and other shipboard use where specifications limit manufacturers to a few relatively expensive but excellent materials of construction, where space limitations are understandably imposed, where automation and other control devices have not been applied and where high steam economy has generally not been paramount.

We propose that significant advances can be made through the actual construction, installation and operation of large land-based pilot plants based on cycles which are known and proven in service. The Griscom-Russell design enjoys this advantage. It is our opinion that basic research into other promising processes should be continued but that it is time to take the process which continues to show greatest promise, flash distillation, and actually fabricate and operate several units each of approximately 1 million gallons per day fresh water capacity.

A tremendous amount of information will be gained from the construction and operation of the first unit. It will be shown realistically that, from projected designs, some cost estimates were too high, some

too low, that the designer was too conservative in some cases. In some areas doubts have been expressed concerning the successful extrapolation of criteria proven in capacities of less than 100,000 gallons per day into capacities of 1 million gallons per day. In the operation of a full sized plant such doubts would be removed.

Senator ANDERSON. Reading this, you say:

It is our opinion that basic research into other promising devices should be continued, but that it is time to take the processes which continue to show greatest promise, flash distillation, and actually fabricate and operate several units each of approximately 1 million gallons per day fresh-water capacity.

We have had some other testimony here today from Dr. Badger who said he was ready to start off building one of a million-gallons-per-day capacity. This resolution only contemplated one plant that might be built, of some reasonable size. We left it to the Secretary of the Interior to determine what that would be. There are 3 or 4 horses I would like to put in the race, but was perfectly willing to select only 1. I judge it is your tetsimony—and you can correct me if I misstate it—that you also believe that the Secretary of the Interior could pick at least one and perhaps more?

Mr. GARDNER. Yes, sir.

Senator ANDERSON. And run inexpensive tests, at about a million gallons, and try them out and see what develops by test run to see how they will work?

Mr. GARDNER. Yes, sir. I believe that 2 or perhaps 3 plants of a million gallons per annum each, utilizing distillation cycles, could be built for the proposed $10 million.

Senator ANDERSON. In addition to that, Senator Case had a bill with reference to brackish water only. You are talking about sea water here?

Mr. GARDNER. I am.

Senator ANDERSON. He was concerned with brackish water only, and you mentioned the fact that there had been those who had been dealing with the processes which you think is more ideally suited to brackish water. You think there is at least one process that might be tried out there?

Mr. GARDNER. I do, on brackish water.

Senator ANDERSON. So that there need be no conflict between the bill of Senator Case and myself, and there need be no conflict between our bills and the work now done by the Office of Saline Water?

Mr. GARDNER. I agree with that, too.

Senator ANDERSON. We don't want to disturb that any more than you do. We want that work to go on. But as far as I am concerned, I think we have reached the point where we ought to take a further good-sized jump and see if these things don't work. I think we will learn something in the building, and we might be surprised how well they work. If 2 or 3 processes should happen to work, that wouldn't break my heart. That would indicate that we are farther along than we thought we were. You are ready to start one with a million-gallon capacity?

Mr. GARDNER. Yes, sir. Our firm is presently quoting plants of that capacity at firm prices. I wish I could say that we had landed one of those jobs but we have not yet.

Senator ANDERSON. Would you mind indicating in what general neighborhood the price is? I don't want to get down to competitive

quotations. What general neighborhood would a million gallons run, if it were to be built on the east coast, in the neighborhood, let us say, of New York, or on the west coast, in the neighborhood of Los Angeles?

Mr. GARDNER. I would say that a million-gallons-per-day plant, built of materials which have been proven to be good on sea water, with a guaranteed service life of 20 years, the capital investment in distilling plant equipment only would be in the order of $1,600,000. I am not talking about site preparation nor boilers.

Senator ANDERSON. That is a very useful figure. I am not trying to pin you down here too closely. If the Government were to authorize the construction of a million-gallon-capacity plant at a cost of $1½ million or $1¾ and somebody else prepared the site, you would have to have additional money for that, and you started to operate, have you any thought as to what the operating costs might be, bearing in mind that they will be far higher on this million-gallon capacity than they would be on a larger plant?

I am trying to see how much would have to be sort of subsidized through the years to get it down to test the theory that you have. Would it be 50 cents, 75 cents, $1, $1.50 per thousand gallons of water?

Mr. GARDNER. Mr. Chairman, in combination with electric-power production—talking along the same lines Dr. Badger did—we believe the costs would be approximately 90 cents per thousand gallons. This again is using materials about which there is no doubt as to their suitability. Cheaper materials of construction would reduce the cost. And I believe that the demonstration plants should be built of cheaper materials of construction, and not of the ones that we are fully prepared to guarantee at the moment.

Senator ANDERSON. I think that is a proper attitude to take, because if it works, if the process works, a million gallons is not the ultimate size.

Mr. GARDNER. No, sir.

Senator ANDERSON. It is only a step. Therefore, we don't need to be saddled with 20 years of operation such as you would build in a plant for a steamship or submarine.

That is helpful and I appreciate it.

Mr. GARDNER. With reference to expected costs of fresh water, the Griscom-Russell Co. is qualified to speak on the single-effect, low-temperature, difference flash distillation cycle and on multiple-effect, flash-distillation cycles operating with exhaust steam from a power-producing turbine. Valuable information on the costs of a single-effect, low-temperature flash process was developed under contract with the Office of Saline Water.

This cycle is based upon the existence of very large quantities of water at two different temperatures. With a 30° F. total temperature difference between the incoming warm water and incoming cooling water, cost estimates using the Office of Saline Water standardized cost procedures show that water can be produced by this process for approximately $1.20 per thousand gallons. This cost includes all of the items required to be included by the OSW standardized cost-estimating procedure.

Based on work we have conducted on our own initiative using multiple-effect flash distilling units taking the exhaust steam from a

turbogenerator set, the total costs for producing water are 90 cents per thousand gallons. This cost includes all appropriate charges and is based upon fuel costs of 25 cents per 1 million B. t. u. as outlined in the OSW standardized procedure. It should be noted that the preceding costs do not depend upon the successful proving of any hopeful assumptions. They are based on proven cycles, proven materials of construction and conservative cost-estimating procedures. Lower costs have been estimated for other distillation cycles but we believe they have been based on the development of successful scale-prevention methods and on the use of carbon steel construction throughout.

The advantages which will accrue from the enactment of this legislation are:

(1) Accurate cost data will be made available concerning installation, operation, maintenance, and repair.

(2) Estimates of capital costs of distillation equipment will be confirmed.

(3) The type of engineering data which can only be acquired through the construction of full-size units will aid in reducing costs of future units.

(4) The suitability of cheaper materials of construction will be determined.

(5) The existence of demonstration units in this country will stimulate the use of saline water conversion processes in other water-short areas of the United States. I make that point because there are many distillation units presently being installed and already operating abroad, but I believe a small municipality in the United States would have much greater faith in something he could go see right in our own country. That is why I believe that would stimulate the further use of distillation.

Senator ANDERSON. You would be operating it at the standards of the American workingman and the wages of the American workingman, and give them a much better yardstick as to what the operation might be here in this country.

Mr. GARDNER. Yes, sir.

My last point: We assume, of course, that demonstration units would be installed in locations needing supplemental water supplies, and the units would help meet that need.

The Griscom-Russell Co. believes that progress in the production of low-cost fresh water should be hastened and that the Federal Government could encourage acceleration of progress by the enactment of legislation which would authorize the awarding of design contracts as necessary to permit a thorough evaluation of several distillation cycles, followed by the actual fabrication, installation and operation of several units, each of approximately 1 million gallons per day capacity.

That concludes my statement, Mr. Chairman.

Senator ANDERSON. That is a fine statement.

Senator Case?

Senator CASE. Mr. Chairman, there are two questions which suggest themselves to me.

First, there are some communities, of course, where they have a water supply and they have to put in a filtration plant.

If you found a community where the choice was between a filtration plant with a questionable supply of water as far as quantity is concerned, but the opportunity to use sea water, if the sea water could be used, would it be fair to subtract the cost of a filtration plant from the cost of one of these plants treating sea water for comparative cost purposes? You wouldn't need a filtration plant I assume if you went to distillation?

Mr. GARDNER. No, sir. That is one of the things about distillation. We can make distilled water, completely distilled water from sea water with not much more money than we can make distilled water from brackish water.

The gentleman from Ionics pointed out that costs in the Ionic's processes are a function of the initial total solids content of the feed water.

Senator CASE. With your method you would get purification of the water for meeting sanitary requirements without any additional cost over that which you would use simply to take out the hardness and make water soft?

Mr. GARDNER. That's right, sir. The distilled water product has been shown to be completely safe for all potable purposes and it is presently being done that way in almost every ship that is built.

Senator CASE. With reference to your final point, No. 6, you suggest that: "It is assumed that demonstration units would be installed in locations needing supplemental water supplies, and the units would help meet that need." I was wondering if it might not be possible to find a community where they have the problem of providing additional water supplies who might not be interested in a cooperative venture, where the Federal Government might provide part of the cost for a demonstration plant but at the same time they might make some contribution because it would meet, or help meet, their need for supplemental water supply?

Mr. GARDNER. To get back to your previous question: If there were some doubt as to the adequacy of the supply of a well water which had to be filtered, and if this location were adjacent to a seacoast, if I were in a position to make the decision I would certainly go to distillation, where I have an unlimited supply of feed to use.

Senator CASE. Probably then the community could consider the saline in industrial uses of the water, saline on plumbing costs, boiler costs, and things like that, by using distilled water over simply a water which was purified from a sanitary standpoint?

Mr. GARDNER. Actually in a municipality water supply I suspect the distilled water would be cut back, so to speak, with available brackish waters.

Distilled water is corrosive in itself in most instances, and it is rather flat in its taste, that is, highly distilled water. I imagine in a municipal water supply just to make the water more palatable the product would be mixed with——

Senator CASE. With selected salts?

Mr. GARDNER. With some quantities of existing brackish water supply to provide a mixed water for distribution to homes.

Senator CASE. But selected so that the salts would be palatable rather than otherwise?

Mr. GARDNER. Oh, yes.

Senator CASE. Mr. Chairman, I brought that out because it seemed to me that as this matter was explored it might be that we could get more than one plant if we could find a community where something of this sort would make a contribution toward solving a problem.

Senator ANDERSON. I think it is a very important point, because it does solve the problem.

Mr. GARDNER. I make the point because we have absolutely no doubt about the fact that this plant will work, so that you might as well put it somewhere where the product can be used.

Senator ANDERSON. Thank you very much. We appreciate your being here.

We will put in the record a statement from the National Aluminate Corp., submitted by Walter M. Hertel, vice president, and F. K. Lindsay, assistant vice president.

(The document follows:)

STATEMENT OF NATIONAL ALUMINATE CORP.

ITEM NO. 2. DEMINERALIZATION OF BRACKISH WATERS IN THE INTERIOR FOR IRRIGATION, INDUSTRIAL, AND DOMESTIC PURPOSES

We believe that the present state of development of the electrodialysis process suggests that it is most applicable, and best suited economically, to the conversion of brackish water found in the interior of the country. In fact, the electrodialysis process appears to be best suited of any of the processes currently under consideration for the conversion of brackish water. Depending upon the salt content of the water to be treated, and on the percentage of salt reduction required, the cost of producing usable water by this process is stated to be from 25 to 60 cents per thousand gallons.

Electrodialysis as a saline water conversion method is relatively new. Considerable work has been done on this method in recent years in the United States as well as in England, The Netherlands, France, South Africa, Italy, and Israel. Much of this work was reported in papers presented at the symposium on saline water conversion conducted by the Office of Saline Water, United States Department of the Interior, and National Academy of Sciences—National Research Council held in Washington, D. C., November 4–6, 1957.

The main factors entering into saline water conversion cost in applying the electrodialysis method are: (1) amortization of initial plant cost; (2) perm-selective membrane replacement; (3) electric power consumption. Of these factors, the first two constitute a high percentage of the total. We feel therefore that a study should be made of plant construction costs employing plant design already developed by such well known groups as Ionics, Inc., of Cambridge, Mass., and the Central Technical Institute (TNO) of The Hague, Holland. To this end, we suggest the erection of plants, of the designs referred to, to operate on brackish waters of comparable salt content.

Membrane replacement cost, the second factor referred to above, is dependent on the initial price of the membranes, their physical and chemical stability and length of operating life. Inasmuch as considerable improvement has taken place in membrane development in the past 2 years, a study of membranes of varying intial costs, with varying physical and chemical characteristics should be carried out in the plant installations referred to above, for their influence on water conversion costs. It should be noted here that the operating characteristics of the membrane used can also effect the efficiency of the operation of the electrodialysis cell.

The National Aluminate Corp. is the leading manufacturer of water treating chemicals in the United States. Inasmuch as we build no mechanical equipment, we have made no comprehensive study of large scale complete electrodialysis plants. We have, however, spent considerable research time and money over the past 5 years on the development of the perm-selective membranes which are such an essential part of the complete plant.

Senator ANDERSON. The last witnesses this afternoon are Mr. O'Leary and Mr. Williamson, of the Maxim Silencer Co.

STATEMENT OF F. R. O'LEARY, MAXIM SILENCER CO., ACCOMPANIED BY W. R. WILLIAMSON

Mr. O'LEARY. Mr. Chairman, I wish to express our appreciation for being asked to participate in this discussion.

We have offered a presentation in accordance with the requests of this committee which we ask to be placed in the record.

Senator ANDERSON. That will be done at this point.

(The document referred to is as follows:)

PREPARED STATEMENT OF THE MAXIM SILENCER CO., HARTFORD, CONN.

For many years man has struggled to find a practical means of converting sea water to water of sufficient purity for human, agricultural, and industrial consumption. Since 1952, the United States Government through the concerted effort of the Department of the Interior, Office of Saline Water, has attempted to explore and refine the many and varied processes which have been developed for this purpose. In November 1957, the Office of Saline Water and the National Research Council conducted a symposium on the subject to report on and discuss the status of the art to that date.

The findings of this meeting are a matter of record and it is, therefore, not necessary for us to go into them in this presentation. However, two basic facts were resolved which are of vital importance to this hearing.

1. Thermal distillation appears to be the most practical method of converting sea water to fresh. By sea water we mean water with a solids count of between 30,000 and 35,000 parts per million. An efficient thermal distillation process will refine this water down to a soft, pure 5 parts per million or less.

2. The ionic membrane process appears to be the most practical means of converting brackish water or waters of no more than 4,000 parts per million. Such a process is capable of ultimately producing water of 100 to 150 parts per million which is considered quite potable.

As manufacturers of thermal distillation equipment, this report will dwell primarily upon distillation.

The art of thermal distillation goes back a great many years. In 1627, Lord Bacon observed, "With a heat sufficient for distillation, salt will not rise in vapor." Many of the practical methods developed for obtaining fresh water from salt water depend on Lord Bacon's observation and also the theories on "cold produced by evaporation" advanced by Dr. Benjamin Franklin in 1757 and 1758. These early scientific findings provide the basis of our present-day science. In 1790 Thomas Jefferson outlined in a "report on converting salt water to fresh" a device known as Captain Chapman's Simple Contrivance. This contrivance could be made from materials to be found on any ship, and although the operation was crude it is strikingly similar to the refined processes we use today.

Sea-water evaporators have been used generally aboard ship for over 100 years. We mention this background just to emphasize that the fundamentals of thermal distillation are not new.

The use of sea-water evaporators on shore, however, is rather uncommon and very few large installations are in operation in the world today. All are located outside the United States. One plant on the island of Aruba has been supplying fresh water for general municipal purposes for almost 20 years. Once again this is hardly a new concept, but the equipment used is considered rather crude in the light of present-day developments.

For example, it requires a staff of 17 men to continually clean the salt scale from this installation.

In order that you may be able to appreciate the rapid advance in this field in the past 20 years, the following cost comparisons should be clearly noted.

1. A distillation plant installed in the principality of Kuwait by Westinghouse several years ago is reportedly producing fresh water from the sea for $4 a thousand gallons.

2. The aforementioned Aruba plant is said to produce water for $3.50 a thousand gallons.

3. A new Westinghouse installation about to be started up in Kuwait will produce water at $2.80 a thousand gallons according to current estimates.

4. The largest single sea-water distillation plant in the world, capable of producing 2,700,000 gallons per day, will be put into operation as a second plant in

Aruba within the next few months. This is a combination water and electric power plant, and it is estimated that the cost of producing water will be approximately $1.75 a thousand gallons. If credit is taken for the electric power sold, this cost will reportedly be reduced to somewhat less than $1.50.

5. In early February of this year, the Maxim Silencer Co. submitted to the Secretary of the Interior a design for a 500,000-gallon-per-day sea-water distillation plant which will produce pure water for $0.88 a thousand gallons when the costs are computed in complete accordance with the Office of Saline Water standard procedures. Some of the components of this formula are more conservative than is necessary with our design; therefore, if costs are developed in accordance with what we believe to be current commercial practice, the figure becomes $0.63 a thousand gallons. In other words, my company would be pleased to accept a contract today to produce a plant of 500,000 gallons per day (or in larger multiples of this size on the basis of this latter calculation).

Although the development of the art has moved rapidly in the past decade, indeed in the last year, further cost reductions will now be on a much smaller scale. Efficiencies (the amount of fuel required to produce a given amount of water) are now reaching a plateau, and further explorations into more practical basic materials are likely to be tedious. Further advances will, of course, be made, but additional cost reductions in the next few years will be in pennies rather than in dollars.

Actual water-production costs obviously vary dependent upon some of the factors affecting each individual distillation plan. For example, our company has recently installed a relatively small plant (rated at 16,000 gallons per day) in a hotel in Bermuda. In this instance, steam to power the evaporator is taken from the hotel's boilers and the necessary sea water from the air conditioning system. Hot water is supplied by the evaporator to heat the hotel and operate the laundry, and the residual brine is pumped into the swimming pool to warm it during the spring and fall months. When normal cost credit is taken for these extra functions, the hotel pays only 60 to 65 cents a thousand gallons for its distilled water.

Prior to the installation of the evaporator, this hotel was forced to barge in water at costs as high as $8 a thousand gallons. It has now been estimated by the hotel manager that the new evaporator will pay for itself in less than 3 years.

The foregoing comments have been offered in an attempt to clarify our belief that practical designs exist today with which to produce large-size demonstration plans. The time has definitely come to build such plans to prove the practicability of the idea and to assist in the further development of the art. It is obvious that the lowest costs quoted to date cannot always compete with the cost of natural water, but they are sufficiently low to make sea-water distillation practical in many areas. As a direct comparison, the cost of producing electric power by means of atomic energy is fabulous as compared with the use of fossil fuels. In spite of this fact, large and very costly nuclear powerplants (i. e., at Shippingport, Pa.) are being built today to demonstrate the practicability of the idea and to assist in the further development of this art. Sooner or later the sea-water distillation processes which have been so well refined and engineered must also be taken from the test tube and small capacity plant stage and be applied in the installation of full-scale demonstration units.

There are areas in the United States and its possessions which would greatly benefit right now from the installation of large sea-water distilling plants. This has been a matter of serious study by the Maxim Silencer Co. for the past year. Our investigations have disclosed that the following general areas are worthy of your serious consideration.

1. The southern California coastal area from Los Angeles to the Mexican border. The population is currently increasing in this area at the rate of 1,000 people a day. The deepwater wells along the coast have been depleted to the point that they are now 100 to 200 feet below sea level. This condition has prompted encroachment from the sea with obvious serious consequences. On the eastern edge of this area, the lack of water has permitted an advance by the desert. We are satisfied there are at least three locations in this area in which installations of sea-water distillation plants would be practical today. They are as follows:

A. The city of San Diego: This municipality currently uses approximately 25 million gallons of water a day. The basic supply comes from the metropolitan water district and the water source is the Colorado River aqueduct. The water is relatively poor and contains about 800 parts per million of solids.

The mayor of the city and his scientific advisory committee have studied the problem at considerable length, and believe that a plant capable of producing approximately 2 million gallons a day would be very valuable to San Diego at this time. As the increase in population has also forced a requirement for additional electric power, it is conceivable that a joint water and powerplant could be built in conjunction with the local utility company. We have reason to believe that financial assistance for such an installation might be obtained from the city and/or State of California.

B. The Malibou-Calabasas-Agoura area: A sea water distillation plant of approximately 2 million gallons per day, located on the beach in the general area of Malibou could supply water to this area which covers an approximate 90,000 acres. At the present time the population growth in this area is seriously restricted primarily because of the water shortage. The only water presently available is brought from deep wells and contains as much as 3,000 parts per million of solids. Most of the potable water must be brought in in 5-gallon bottles at a cost to the populace of approximately 20 cents a gallon. Even along the coastline, where water is slightly more available and of better quality, one local water company has recently advised all parents that their children should not drink tapwater because of the high chlorination. The land is extremely fertile and the air smog free. It is only 30 miles from Los Angeles and with good water it could be an excellent residential area for the rapidly expanding population. At the moment this land has little or no value because there is no potable water. Once again, electric power demand is rising to such an extent that it might be possible to collaborate with the Southern California Edison Co., which firm is thoroughly familiar with the water problem in this area. As a matter of fact, they have prepared an interesting detailed report on the subject. From a financial standpoint, perhaps assistance could be obtained from the State of California or possibly the county of Los Angeles.

C. Camp Pendleton, United States Marine Corps: It is our understanding that there is a serious shortage of water in this area and that the Federal Government is currently involved in litigation over the right to the water of the Santa Margarita River. This court action, involving the town of Fallbrook, has already cost $1 million in legal fees and could cost considerably more. It is further our understanding that a sum of $20 million has been appropriated by the Congress for the construction of a dam on the Santa Margarita River to alleviate the situation, but that no construction action has actually been taken nor will it be taken until the litigation is resolved. A sizable sea water distillation plant installed here to supply the Marine Corps would not only help resolve this matter but would appear quite important to the defense of the country. Perhaps financial assistance could be obtained from the Defense Department for such an installation.

2. The southern Florida coastal area. Here there appears to be one outstanding requirement in the city of Key West. All of the water supplied to this city and to the United States naval station there comes from a 130-mile pipeline. This line is old and in constant need of repair and replacement. Maintenance costs are staggering. Pressures at the head of this line have had to be raised so high, it is estimated that 10 percent of the water is lost through leaks before it reaches its destination. At the Key West end of the line the pressure is so low that booster pumps have to be provided even in individual homes. In spite of this inadequate supply and its possible effect from a national-defense standpoint, it is our understanding that the United States Navy feels it cannot authorize sufficient funds for a replacement line. They are vitally interested, however, in the water problem and it is conceivable that collaboration with this Government department might be acceptable. The city-owned powerplant has recently been expanded and we would consider the erection of a sea water distillation plant in conjunction with this powerplant very practical by utilizing the waste or bleed steam from the present turbines. Adequate capacity is available for this. The present cost of water in Key West is very high. It is sold to the consumer at $1 a thousand gallons and we doubt very much whether anyone in the town would refuse to pay considerably more if they could be guaranteed an adequate potable supply.

3. The Caribbean Island area: Very few islands in this area have enough water. The natives have put up with poor and inadequate water supplies for years, but if the area is to be developed as a tourist or industrial area, more and better water is an absolute necessity. This has recently been forcibly brought to our attention in the installation of a Maxim distillation plant on the island of

St. John in the Virgin Islands. Although large catchment areas had been provided here, the rainfall was so inadequate that water had to be barged in from Puerto Rico at a cost of $15 a thousand gallons. In spite of the obvious high fuel cost in this area, due to transportation difficulties, the new distillation plant will provide water for a cost of approximately $2 a thousand gallons.

The Virgin Island territory appears to be an excellent one for a demonstration plant. A real need exists on the island of St. Thomas where discussions on this particular subject have encompassed the past several years. The requirement is for 250,000 gallons per day. A shortage of power is expected to exist in this area, and plans are currently underway for the expansion of the electric facility by means of providing additional large diesel engines. The construction of a combination water and powerplant at St. Thomas might represent a real saving to the Federal Government.

The sum of $10 million has been suggested as the appropriate amount of Government funds with which to implement this demonstration program. It has been suggested that financial responsibility be shared wherever possible. In view of this, it would seem logical to us that the soundest program would be to build not 1 but 3 sea water distillation plants under this program, one to be located in southern California, one in southern Florida, and 1 in the Caribbean area. Plants of appropriate sizes could in all probability be constructed in these areas for the sum contemplated and would leave a sufficient balance for the erection of an ionic membrane plant to further study the problems of converting brackish water.

At the outset of this discussion it was pointed out that whereas the thermal distillation processes appear most practical for the conversion of salt water, the ionic-membrane processes apparently offer an excellent means of converting brackish water. This is particularly true in areas remote from the sea where severe water shortages now exist. A disadvantage, of course, of this particular process is the fact that it must draw its source water from the rapidly receding ground-water table, whereas the sea water distillation process depends upon the sea, our only natural resource of unlimited size.

Many wells in the Midwest farm area and in the great southwestern desert area have been depleted to the extent that only brackish, semisalty water remains—water unfit for human consumption or for irrigation. In such an area where well water can be obtained in sufficient volume, it would be our suggestion that a membrane plant of large size be installed. Such a plant could dispense water in such a way as to create a veritable oasis in the desert and prove that with proper irrigation and care the land can be reclaimed. A model plant of this type, together with the restored areas surrounding it, could serve as a prototype for many other such installations where the current lack of rain has actually ruined the economy of sizable areas.

It is our conviction that the above described plan is a practical one.

It would greatly abvance the 2 methods of water conversion considered today to be the most practical, and it would permit the installation of 3 types and sizes of distillation plants. These plants would be of sufficiently large size to demonstrate in all respects the practical aspects of each design, and to prove their economic potentialities insofar as municipal or other very large-scale applications are concerned. There is little doubt that these four projects can be accomplished within a 2-year period after initiation for the proposed sum of $10 million.

Reputable American manufacturers and engineers are ready today to accept contracts for this work. It is hoped that appropriate action can be taken by the Congress without further delay to institute this practical solution to a problem that has become so vital to our economy and to the growth and strength of so many of our allied nations.

Mr. O'LEARY. I would like to make some oral observations to summarize my statement.

I feel that the simplest way to say what we have to say is that we, Maxim Silencer Co., have no specific argument with Dr. Badger or his approach to the method of distillation. It has been quite well established that avid control, regardless of how you approach it, has distinct advantages in the reduction of scale.

23642—58——8

Likewise, we have and are willing to admit that under brackish water conditions, ionics, or the electric membrane process, has a distinct application which must be recognized in economics over and above that which is normally presented by distillation processes.

We know that thermal distillation appears to be the most practical method of converting sea water to fresh water. By sea water we mean solids between 30,000 and 35,000 parts per million. An efficient thermal distillation process will refine this water down to soft, pure, 5 parts per minute or less water.

The gentleman from Griscom-Russell approaches this equivalent problem in a slightly different way than we in Maxim Silencer approach it. We in Maxim approach it having acquired a distinct knowledge of the idiosyncrasies of the production of fresh from salt water by many years of application of these particular processes. We were and are suppliers to the first people who had the requirement, namely, the United States Navy, the Coast Guard, for their particular purposes. And in the many applications that we had with these gentlemen, we learned many things you can do and cannot do. It was a training school that, thanks to our support in the Navy, was an exacting one. When they were at sea, the unit must work or the boilers are jammed and the ship is in trouble.

These people have been contracting, and they have developed requirements that have cost money, no doubt, as to the potential application to land-based installations.

In many cases the ultimate requirement of the Navy can be simplified for land-based installations. The product and analysis that has been done by the marine laboratory of the Maxim Silencer Co. in the past few years have been an evaluation of the economics of the respctive systems, the economics of the respective approaches, in order that municipal or large-scale applications, to use scale in a horrible way, might be practical and justified for water-short areas.

What the Maxim Silencer system is is the system which is the most economic for the specific set of conditions, parameters, that are set up by the requirements.

As I previously said, we would not argue with Ionics or the electric-membrane processes in brackish waters because we believe that is the approach to brackish waters.

We do feel that we are able to prove, by actual installations and by long-term evaluation of the parameters, the fact that scale does and will form and provisions must be made to eliminate that scale.

Maxim has arrived at methods and techniques for properly eliminating that scale. These techniques vary, depending on the particular set of circumstances that are presented.

The Maxim system will work on brackish water as well as on salt water, but not with equivalent competence.

The organization that I and Mr. Williamson represent here believe that the proper approach to land-based units is to have a multiplicity of these units, of those which are presently recognized to the best potentials economywise, and prove those particular systems in respective areas under conditions of normal operation. And by normal operation I do not mean test-tube operation, I mean operations of sizes that are commensurate at least in units with those which would be present in a real large scale application. I am thinking of units

at least 550,000 gallons capacity per unit, and those in multiples, two of them being a million gallons roughly.

Senator ANDERSON. You have said that the membrane processes might be desirable in brackish water, so I will eliminate Senator Case's bill for a moment and say that if my resolution should pass and the Secretary of the Interior should make a study and decide that the process which you people have sponsored was one that he wished to test out, are you far enough along so that you could, within a reasonable time, be ready to design for a million gallons by say two 500,000 gallon units, and that you could construct it and have it prove something with reference to this program?

Mr. O'LEARY. We have quoted units as high as 15 million gallons. Those units are completed as far as existing basic fundamental engineering design is concerned. The components which are in that large unit are designed, tested, and we have knowledge of the conditions of performance arrived at by extensive testing in our Mile Stone Point Laboratory in Connecticut.

Senator ANDERSON. So that you don't think that there is any need to wait for several more years before we build one with a million gallons' capacity?

Mr. O'LEARY. I know that we have answers to the problems which are presented in a million-gallon capacity because we have already built, sold in some cases, all of components which would be present in the million-gallon-capacity unit. The million gallons would be a multiplicity of these components. And that is all. Each of the cells has been tested. There is now operating on the island of Bermuda a Maxim unit which is yielding water today in excess of our anticipation—our anticipation was 14,000 gallons per day, and it is yielding something over 18,000 gallons per day, that water being of four parts per million impurity, so-called, off of sea water, and it is doing it at costs of around 45 cents a thousand gallons. These are not our figures. These are the figures of the people who are paying the bills.

We have taken plants as high as 500,000 gallons' capacity and calculated their potential operating cost in accordance with the procedures set up by the Office of Saline Water and endorsed the figure of Griscom of 90 cents, because our figure is 88 cents. We agree with much of the factors as applied to the saline method, and believe if the factor is properly applied, costs as low as 63 cents per thousand gallons are potential.

Senator ANDERSON. That is very interesting. They apparently have been seriously figuring it, and conscientiously figuring it, and so have you, and you come out with a figure that makes it attractive, it seems to me, not as far down as it could go, but certainly not as far from the goal as the electric figure I quoted today is from commercial power.

Mr. O'LEARY. Another thing that is important. Take the exact qualification Mr. Gardner took on Griscom-Russell. These figures that we are now quoting are figures that we say commercial organization would present to an individual commercial customer, and warrant and guarantee their performances.

If we were able to stick our neck out, to use a phrase, as we might want to do in a development or prototype plant—I do not like the

word "prototype," developmental plant—many potentialities exist, with little risk to materially reduce that cost, materially reduce that cost. I have a hard time with my chief engineer, Mr. Williamson, to keep from getting through about specific materials or specific approach to a problem if I, as a gambler could take the gamble, it might work. But I, as a commercial supplier, having a warranty or guaranty responsibility, cannot afford to take the chance. We have taken many of those chances in the laboratory. That is how we arrived at the position we are at. We have done this on our own. I won't quite say that. We have done this on our own to a large extent, but we have had in many cases the backing of the United States Navy who asked us to solve specific problems.

We learned many things as a result of this money. We supplemented that money with our own money. The net result is that we believe that the separation of salt to fresh water is a practical thing. We think it is economically justified in many areas of this world. We think that the net result of a prototype development test plant, whatever you want to call it, of a practical size, would be to accelerate the rate at which the reduction of costs can be attained.

It is quite common in engineering approaches that you have got to take the engineer's brainchild away from him in order to have a child nurtured in proper status. They will also fiddle and diddle. You must get it out, put it to work, and make the economics of the situation be the irritant that causes the invention or the state of the art at a proper rate.

This is why we completely endorse the approach that has been generated by your bill, sir, and frankly, we are quite enthusiastic about the rate of change that would result in the state of the art if this bill were successful.

Senator CASE. That is a good statement.

Senator ANDERSON. Thank you, very much.

Senator Case?

Senator CASE. Mr. Chairman, in listening to the witnesses here recently, it occurred to me that we have been talking in terms of either distillation or the membrane process. With the distillation, you achieve a complete elimination, you might say, of the salts; do you not?

Mr. WILLIAMSON. That is correct.

Mr. O'LEARY. Sir, in distillation, you can get down to less than 1 part per million, which is just about as complete as you want to be.

Senator CASE. Of course, for domestic or industrial use, that certainly is not objectionable, and since it doesn't add to the cost to get practically salt-free water, that is a goal to consider.

I am thinking of the problem, however, of water for irrigation. I recognize that the costs we have been talking about are too expensive when you think of irrigation water. However, if there were a process which could get part of the job done, reduce the salts to a figure within the tolerance that is permitted for crops, or if we had a process which could convert harmful salts into a salt or into a form of mineral composition that could not be objectionable, would we use distillation or would we have to go to some other process?

Mr. O'LEARY. The approach that looks now to be the most advantageous on that, sir, is distillation with blending. By blending, I

mean taking some of the large mineral-content water and blending it with low-mineral content water and coming out with a passable or acceptable minimum content water at much lower cost per thousand gallons of net water. But passable water——

Senator CASE. Dilute it. Diluting it. It is the old blend situation. Cutting it, in other words.

Senator ANDERSON. That ignores Senator Case's suggesting that there are certain salts which are harmful to crops, and others which are not. He wondered about the possibility of transposing those harmful salts into harmless salts.

Mr. O'LEARY. I know of no way to do it except by additives. You blend them to minimize them and in some cases, minimize them by additives or eliminate them in that respect.

Senator ANDERSON. It is an interesting field.

Mr. O'LEARY. Ionics, in their approach, finish up pretty much with the same situation. They would finish up with parts per million of selective parts, anything from 40 to 500. The distillation process will finish up with anything from about 5 to less than 1 part per million. In some areas of the country, particularly in the island of Aruba, I happen to know they took blended water for taste reasons. Likewise, some people were of the opinion that the elimination of all of the minerals, or a very large content, was not particularly advantageous to health.

So, on that particular circumstance, there was an agreed blend of raw sea water with the distillate. The net result, I am told, and I haven't tasted it, is a very acceptable water.

I do not, however, want to get the idea across here that water, so-called distillate water, is bad tasting. Distillate water is flat, but distilled water aerated is to most people not discernible from normal tap water, except maybe in an area where it is 800 parts per million. Then, it is usually obvious. But under good city water from 90 parts per million down to 4 or 5 parts per million, you can't tell the difference if it has been aerated.

Senator CASE. I think aeration improves the taste quality of a great many waters. If you have hidden springs, it is a good idea to have a chance for air to get to it.

Mr. O'LEARY. We took in, for the sake of information, a group of our employees to offset this bugaboo that distilled water doesn't taste good, and mixed up some distilled water, properly aerated against tap water and tried to have them tell us which was which. Frankly, it was a 50–50 tossup; they didn't know. This one was sure it was tap water and this one was sure it was distilled water. They were just about half wrong.

Senator CASE. Mr. Chairman, I just mention, perhaps to keep in sight, while we proceed with the hearings, none of the figures that have been suggested yet would of themselves suggest that the process would give you water you could use for irrigation. But possibly by dilution, and I think perhaps even more so by some process which converts some of the salts, we might approach the problem of the irrigation water, too.

I have in my possession a letter from a farmer who received a soil conservation award a year or two ago where he had done some experimentation by additives, I suppose, to convert some of the salts. To-

morrow I will seek to introduce that in the record and will then ask the Office of Saline Water to give it some consideration and perhaps prepare some comment on his approach.

Senator ANDERSON. I think that is very interesting. I hope that anyone who is here who has picked up an interesting paragraph or two in some trade publication or otherwise that might add to this hearing would submit it to the committee so that we might incorporate some of them into the hearings.

Mr. O'Leary, last fall I believe there was a story that circulated to the effect that Maxim had a process that was looking toward 20 cents a thousand gallons. I don't hold you responsible for news stories any more than I hope I will be charged with all of things I have seen attributed to me. Would you care to comment on that?

Mr. O'LEARY. Yes, sir, I would.

The story, 20 cents a thousand gallons, attributed to Maxim, was a story in which the figure was taken entirely out of context. There was a local reporter who came to Maxim knowing that we were potential suppliers of systems for reduction of salts to fresh water, about the time the symposium on saline water was starting, and had a discussion with us as to a local news story.

This gentleman asked us what the water would cost. We advised him that in our opinion the water would be about $1 a thousand gallons. Then the question came about, what is the $1 per thousand gallons composed of? Fuel cost, amortization, secondary maintenance, and so forth and so forth?

The story that hit the press, or hit the news tickers and wires—it really hit them—was that water could be produced for 20 cents a thousand gallons.

He should have added: with either fuel, basically fuel costs—the actual fuel cost was about 23 cents a thousand gallons. The 20 cents actually was no good figure, other than one that I believe he thought was spectacular.

Actually what it really was, was about fuel costs. It had completely disregarded amortization. And I might say he qualified his story, if you read it real carefully, because the way he put it, it was that if a plant were supplied—by a rich uncle or somebody—and if fuel were available, the plant could produce water for 20 cents a thousand gallons.

If all the "ifs" were successfully transmitted and somebody chose to read them carefully, you would have qualified, or people would have qualified their acceptance of the 20 cents.

Senator ANDERSON. I only wanted to establish for the record that Maxim does not believe that 20 cents a thousand gallons is a sensible price at the present time.

Mr. O'LEARY. No, sir. We do not. We hope to get there, but we don't see it yet. I might say that we in the last 3 years have seen costs of water by recognized processes go from around $4.50 a thousand gallons—provable costs, taking all factors into consideration—to about 88 cents a thousand gallons, provable costs under the rules of the game, no wishful thinking.

We know these costs are high. We know many things that can be and will be done to reduce those costs. There is research needed to prove those things in a way that a commercial organization can accept them as proof.

Senator ANDERSON. Would the things which Senator Case and I suggested in our two bills help to bring that about?

Mr. O'LEARY. I say, sir, that I think this is the fastest way it can be accomplished. The need for these particular things will be made obvious by the dollar sign. The irritants will be supplied. The fact that the systems are out of the test tube and into the application field will cause many people, not just the people in the water business, the chemical people, the metallurgical people, to contribute to this package so that the net gain of the water user is low-cost water. We open the field to others than us who are specifically thinking of it.

Senator ANDERSON. Mr. Williamson?

Mr. WILLIAMSON. May I make a suggestion in line with Mr. Gardner's comments? I think that an ideal plant setup would actually be steam turbines driving generators for operating a membrane technique. Many of our shore installations have brackish wells right near the edge of the water. The exhaust from the turbines could run the thing that Bill suggested, a couple of flash or submerged-tube distillation plants. Then you would have your 2 bills all in 1 package.

Senator CASE. That is an idea, too.

Mr. O'LEARY. This is one of the things that you have in engineering. They are developing all the time. This is exactly the situation that was presented here. The combination of known facts can result in an economic package. Many people still think that people proposing to make fresh water from salt water practice witchcraft. That has changed many, many years ago.

Senator ANDERSON. Thank you very much. I want to thank all the witnesses who appeared thus far. If any of you do not testify and do desire to have statements in the record, please submit them. We do expect to hear all the people who are still on the list to be heard tomorrow.

I will insert in the record my letter of February 10, 1958, to the Secretary of the Interior, requesting certain information, and attach the response which was received from the Secretary under date of March 19, 1958.

(The above-mentioned material is as follows:)

SUBCOMMITTEE ON IRRIGATION AND RECLAMATION,
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
February 10, 1958.

Hon. FREDERICK A. SEATON,
Secretary of the Interior,
Department of the Interior, Washington, D. C.

DEAR MR. SECRETARY: On February 4, I wrote you with respect to Senate Joint Resolution 135 to authorize the Secretary of the Interior to construct, operate, and maintain a full-scale demonstration plant for saline-water conversion. That communication was intended to bring to your personal attention our appreciation of the urgency of action to meet the national water problems outlined, which, I recall, you also recognized in an interview with Gould Lincoln in the Washington Star a short time ago.

You are invited to be present in person at the hearing on the resolution before the Subcommittee on Irrigation and Reclamation at 10 a. m. Thursday, March 20, in room 224, Senate Office Building. A summarization of your views on the water problems is desired for the record at that time, in addition to comments on the Department's formal report on the proposed legislation which was requested by Chairman Murray to be furnished within 30 days. Any suggested amendments will, of course, be considered.

In the meantime, it is requested that you direct the preparation in advance

of the hearings of factual information by appropriate Interior agencies on the national water problem and related subjects. It is hoped you will have present departmental witnesses to present oral summaries in their respective fields, as well as to respond to interrogation on pertinent points in the material. These interrogations will be aside from questions of policy involved in the proposed legislation.

The immediate areas coming to my mind from which summary information is requested in writing by March 10 are outlined as follows:

1. Office of Saline Water

(*a*) Operations and goals or targets under existing legislation.

(*b*) Listing of most promising economical processes of desalting sea water and the demineralization of brackish water with.

(*c*) Comparison of estimates of all costs, including installation, operation, and maintenance, etc., under each goal, with indication of what is considered maximum economical cost per 1,000 gallons and per acre-foot.

(*d*) What progress other countries are making toward the development of economic saline-water processes.

(*e*) Any other pertinent information, specific or overall, that will throw light on the problem and the solutions sought by the proposed legislation.

(The Department's recommendations will, of course, be conveyed in the report on the resolution through the Bureau of the Budget.)

2. Geological Survey

(*a*) Comprehensive summary of national water uses and projected requirements in major categories, such as domestic, municipal, industrial, irrigation, and any other major uses.

(*b*) The most sensitive areas in the country where expanding population, industry, or irrigation activities are accentuating the drain on available normal water supplies.

(*c*) Summary of forecasts of requirements by uses, overall, for specific purposes and in most sensitive areas in 5, 10, or 25 years.

(*d*) Sensitive areas where quality of water for domestic, industrial, or irrigation purposes is a problem.

(Since the Geological Survey is a recognized authority on water resources, its summaries will, of course, be of basic value.)

3. Bureau of Reclamation

(*a*) Irrigable acreage in reclamation projects that has gone out of production or is threatened by alkali, other salts, or brackish water generally.

(*b*) Location and acreage involved in areas where demineralization of brackish water, if economically feasible, might be helpful.

(*c*) Federal investment in irrigation, drainage, or other facilities which is threatened or has been written off as a result of water quality, including Shade Hill Dam in South Dakota.

4. Division of Territories

(*a*) Water problem on St. Thomas, V. I., with existing and estimated potential demand; and how current and past emergencies have been or are being met.

(*b*) Population, resident and tourist, that accentuate water problem on St. Thomas.

(*c*) Alternate plans (summarized) to meet current and future requirements with cost estimates available.

(*d*) Potential solutions considered by desalting sea water or otherwise, particularly with reference to a utilitarian demonstration plant with multiple-purpose possibilities, including augmenting of the power supply for the islands.

(*e*) Summary of any water problems in other Territorial areas.

In order that the factual information requested may be analyzed in advance of the March 20 hearing, it is requested that the contributions of each agency be transmitted to me in triplicate, not later than March 8. We are requesting broad information by that date on the effect of the quality of water on irrigated agricultural land generally in the West from the Department of Agriculture, and appropriate information from other agencies and individuals by that date.

A copy of this letter, as a matter of information, is being sent to each of the four agencies of your Department that is concerned with this request.

Sincerely,

CLINTON P. ANDERSON, *Chairman.*

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D. C., March 19, 1958.

Hon. JAMES E. MURRAY,
Chairman, Committee on Interior and Insular Affairs,
United States Senate, Washington, D. C.

DEAR SENATOR MURRAY: In further response to the letter of February 10 from Senator Anderson, chairman of the Subcommittee on Irrigation and Reclamation, there is enclosed the factual information developed by the Office of Saline Water, the Geological Survey, the Bureau of Reclamation, and the Office of Territories, along the lines requested in Senator Anderson's letter.

We regret very much that we were unable to furnish this material by March 8 in accordance with Senator Anderson's request.

Sincerely yours,

FRED A. SEATON,
Secretary of the Interior.

1. OFFICE OF SALINE WATER

"(*a*) Operations and goals or targets under existing legislation."

The procedure for carrying out the research and development contract aspects of the program was patterned after that of the National Science Foundation and with their assistance. The individual or organization that wishes to carry out research on saline-water conversion makes a proposal to the Office in which the work is described and the estimated cost given. A formal application for Federal aid on a research proposal is made in accordance with a standard form available from the Office. An initial review of screening of the proposal is made by the small technical staff of the Office of Saline Water. If a proposal is feasible technically and conforms to the general scope of the program, it is then sent to outside consultants who are experts in the particular field. These consultants impartially evaluate each proposal in regard to the need for the research, scientific merit, its apparent economic feasibility and its significance to the saline water conversion program. If a favorable evaluation is made by consultants and by members of the technical staff of the Office of Saline Water, a contract is negotiated with the proposer provided, of course, that sufficient funds are available at the particular time.

At the beginning of the saline water conversion program, the cost of converted water which should be considered as the initial criteria for the research program was given much thought. In the judgment of all concerned, it was felt that the beginning criteria for each of the various end uses should consist of the maximum cost of water for that use from other sources. The initial target cost for converted saline water for irrigation uses was set at about $40 an acre-foot because that was the highest known cost of irrigation water at that time. Likewise, the objective cost for converted water for municipal uses was set at about $100 an acre-foot since a few communities were on record as having paid that much for untreated, undistributed water at the city intake. With water for industrial uses, the permissible cost and range is much greater but data comparable to those for municipal and irrigation uses are not available. However, it seems certain that industrial uses will be made of converted salt water first, since some industries can afford to pay more than can be justified for irrigation or municipal uses at present. The more general goal is the reduction of conversion costs to such an extent that continued expansion in the use of converted water for various uses takes place.

"(*b*) Listing of most promising economical processes of desalting sea water and the demineralization of brackish water with—

"(*c*) Comparison of estimates of all costs, including installation, operation, and maintenance, etc., under each goal with indication of what is considered maximum economical cost per 1,000 gallons and per acre-foot."

(*b*) and (*c*). The most promising of the conversion methods now under development include several distillation and membrane separation processes, and one form of salt-water separation by freezing. Laboratory and economic study to date has narrowed the field from some 20 phenomena or processes to 5 broad groups: (1) Distillation through 4 general types using artificial heat; (2) solar-heat distillation; (3) separation of salt water by membrane processes, of 2 or possibly 3 kinds; (4) freezing; and (5) other chemical or electrical means of separation, including solvent extraction.

Reduction of conversion cost may be expected to bring about corresponding increase in the use of converted saline water; as the cost is brought closer to the maximum prices now paid for water from naturally fresh sources, the demand for and the use of converted water will increase. Initially, industrial use is likely to be the major market of converted sea water or other saline waters, so far as the domestic field is concerned. On present facts, such use may begin when the overall cost of converted water is brought within the range of $1 per thousand gallons ($326 per acre-foot.) Further reduction to the neighborhood of 50 to 60 cents per thousand gallons ($163–$195 per acre-foot) may lead to some municipal use, especially to supplement deficient present supplies. A reduction to around 12 cents per 1,000 gallons ($40 per acre-foot) will probably be needed for significant irrigation use. It is likely that a cost that low will first be obtained in the improvement of brackish waters.

Estimates as to cost per 1,000 gallons by various saline water conservation processes in United States (without sale of power or other byproducts)

	1952 existing installations		1957 designed or projected installations		1960–70 anticipated (if further research is successful)	
	Sea water 35,000 parts per million [1]	Brackish 5,000 parts per million [1]	35,000 parts per million [1]	5,000 parts per million [1]	35,000 parts per million, less than—	5,000 parts per million, less than—
Distillation (including solar)	$2–$5	$2–$5	$1–$3	$1.00–$3.00	$0.50	$0.50
Membrane processes	(1)	(1)	6	.80	1.00	.25
Freezing	(1)	(1)	(1)	(1)	.50	.50
Others	(1)	(1)	(1)	(1)	.50	.25

[1] Not developed.

It is essential that several different kinds of processes be developed to meet all of the needs. Various processes are suited to different conditions including local labor and material costs, for providing fresh water from different saline sources in different locations for different industrial, municipal, and agricultural uses in various quantities ranging from small household stills to large plants capable of furnishing millions of gallons per day.

"(*d*) What progress other countries are making toward the development of economic saline water processes:"

Research and development on saline water conversion is under way in a number of foreign countries. The major efforts are listed below:

1. Great Britain—distillation research (particularly scale prevention), electrodialysis, and development of large operational distillation plants.
2. Netherlands, South Africa, and Israel—electrodialysis.
3. France—low temperature difference method of distillation.
4. North Africa, Australia, and Italy—solar distillation.

There is also a report of work on freezing in France, Yugoslavia, and Israel. It has also been reported that Israel plans to undertake research on distillation and electrodialysis. It is also known that there is research activity in saline water conversion in Russia except for some work on standard distillation and electrodialysis processes, little is known.

Progress in foreign countries toward economical processes is not believed to be greater than in the United States. Foreign equipment developed most extensively is that of electrodialysis, now available commercially from TNO and reflected by the fairly large electrodialysis plant for converting brackish water being built in South Africa. Additional details are given in abstracts of papers presented at the recent International Symposium on Saline Water Conversion, and also in the Department's Saline Water Conversion Report for 1957, a copy of which is attached.

"(*e*) Any other pertinent information specific or overall that will throw light on the problem and the solutions sought by the proposed legislation."

Reference is made to the Saline Water Conversion Report for 1957, a copy of which is attached.

2. United States Geological Survey

(a) Summary of national water uses and projected requirements

About 240,000 m. g. d. (million gallons per day) of water was withdrawn from streams, reservoirs, and wells in the United States during 1955 (table 1).[1] Only about a fourth of the water withdrawn was consumed. The water was used for industrial, domestic, and agricultural purposes. The amount is equivalent to 1,500 gallons per capita per day. About 110,000 m. g. d. was withdrawn by industries directly for their own use, and an equal amount was used for irrigation. About 19,000 m. g. d. of the self-supplied industrial water was saline. Eastern industrial areas and western irrigation areas are the greatest water users. Withdrawal uses in the midcontinent region were relatively small.

Many factors will affect the amount of water used in the future. Water supplies having high quality and low cost are developed first, other things being equal. As more and more cream is skimmed off the water crop, additional supplies will require more treatment, more storage, and higher pumping lifts. But critical water needs in sensitive areas will require some developments of poor water at relatively high cost. Rising costs of development will tend to force more efficient use of water for all purposes. Therefore, it is difficult to make accurate forecasts of the increase in water use within the next few decades.

Table 1.—*Water used in United States in 1955, in millions of gallons per day*

Region	Public supply	Irrigation	Self-supplied industrial	Rural
North Atlantic	950	20	4,868	38
Upper Hudson	196	5	1,004	27
Lower Hudson and coastal area	1,720	43	6,228	37
Delaware	720	32	4,840	30
Chesapeake	863	27	3,756	100
Eastern Great Lakes and St. Lawrence	1,520	24	9,005	114
Western Great Lakes	1,770	50	12,770	164
Upper Mississippi	580	29	8,276	200
Southeast	1,340	596	9,822	240
Tennessee-Cumberland	241	27	4,694	70
Ohio	1,620	23	21,891	254
Missouri-Hudson Bay	800	18,000	4,181	380
Lower Mississippi	500	1,120	3,461	70
Arkansas-White-Red	610	4,800	1,978	199
Western Gulf	1,050	12,400	6,173	158
Colorado	190	16,400	279	32
Great Basin	220	11,200	251	39
Pacific Northwest	820	25,800	1,548	103
South Pacific	1,270	19,300	6,296	100
United States	17,000	110,000	110,000	2,500

Source: U. S. Geological Survey Circular 398.

Unquestionably, however, the growth of industry and population will increase water use. Supplemental irrigation in the eastern States, increased use of water for industrial processing, and higher standards of living alone would add to water use even if there were no growth of industry and population. As the cost of water increases, adjustments may be made. Uses which give a low dollar return per gallon of water will give way to uses from which the return is greater.

The President's Materials Policy Commission[2] estimated that water use in the United States will grow to 350,000 m. g. d. by 1975 (see table 2). The Business and Defense Services Administration[3] raised the estimate to 453,000 m. g. d. (see table 3). Woodward[4] estimated that we may require about 597,000 m. g. d. of fresh water in 1980 (see table 4). Woodward's estimates were broken down by regions and showed consumptive use as well as total water use.

Woodward's estimate of agricultural use of water in 1980 indicates that the amount used for irrigation may have to be curtailed in many areas in order to

[1] See Geological Survey Circular 398, estimated use of water in the United States, 1955.
[2] Resources for Freedom, vol. 1, p. 51, President's Materials Policy Commission, June 1952.
[3] Water use in the United States, Business Service Bulletin, U. S. Department of Commerce, Business and Defense Services Administration.
[4] Availability of Water in the United States with special reference to industrial needs by 1980, D. R. Woodward, Industrial College of the Armed Forces, Washington, D. C., 1957.

meet needs for municipal and industrial use. He forecasts a decrease in water use for irrigation in the Western Gulf-Rio Grande area, Colorado River Basin, Great Basin, California coastal region, and upper part of the Missouri River Basin.

TABLE 2.—*Estimated water requirements in 1975*

	Million gallons per day
Irrigation	110,000
Direct industrial	215,000
Municipal and rural	25,000
Total	350,000

Source: President's Materials Policy Commission (June 1952) Resources for Freedom, vol. 1, p. 51.

TABLE 3.—*Estimated quantity of water needed by 1975*

	Million gallons per day
Irrigation	170,000
Public supplies	29,800
Self-supplied industrial:	
Miscellaneous	115,000
Steam electric	131,000
Rural	7,200
Total	453,000

Source: Picton, W. L. (1956) Water Use in the United States, 1900–1975, Business and Defense Services Administration, Business Service Bulletin 136, Department of Commerce, Washington, D. C.

TABLE 4.—*Estimated use of fresh water in the United States in 1980*

[All quantities in million gallons per day]

Region	Gross use [1]				Estimated consumptive use
	Domestic	Industrial	Agricultural	Total	
New England	1,570	11,000	500	13,070	880
Delaware-Hudson	5,080	19,100	700	24,880	1,560
Chesapeake	1,410	9,900	1,300	12,610	1,210
Eastern Great Lakes-St. Lawrence	1,820	34,800	600	37,220	2,130
Western Great Lakes	2,410	55,000	2,300	59,710	6,850
Upper Mississippi	1,380	33,400	10,000	44,780	8,450
Southeast	3,740	60,000	8,000	71,740	7,590
Tennessee-Cumberland	600	18,700	1,500	20,800	1,720
Ohio River	3,110	83,800	8,000	94,910	8,350
Missouri-Hudson Bay	1,450	13,200	28,000	42,650	18,200
Lower Mississippi	1,060	17,700	9,500	28,260	5,680
Arkansas-White-Red	1,080	8,000	10,000	19,080	6,890
Western Gulf-Rio Grande	2,420	14,600	12,000	29,020	9,440
Colorado River	780	1,200	14,000	15,980	9,310
Great Basin	630	1,100	7,000	8,730	4,710
Pacific Northwest	2,370	8,700	36,300	47,370	18,800
South Pacific	6,310	4,000	16,000	26,310	11,300
United States	37,220	394,200	165,700	597,120	125,070

[1] Figures exclude use for hydroelectric power, navigation, and recreation.

Source: Woodward, D. R., Availability of Water in the United States with Special Reference to Industrial Needs by 1980: Student exercise, Industrial College of the Armed Forces, Washington, D. C., 1957.

The following tables are examples of projected estimates of future water use. All estimates of water use 10 to 20 years from now are quite conjectural. They are based on present water use, trends in population growth and industrial activity, and other factors. Projections usually make no allowance for increased efficiency and economy in the use of water.

Moreover, the economy in some regions tends to adjust itself to its water supply. In other regions, development seems to continue in almost complete disregard of the water supply, and increasingly, expensive measures must be taken to import water or otherwise increase the supply.

TABLE 5.—*Use of fresh water in Florida, in million gallons per day*

Use	Amount	
	1956	1970 (estimated)
Irrigation	[1] 1,182	[1] 2,200
Public supplies	300	631
Industrial:		
Electric power	1,590	2,120
Pulp and paper and chemicals	354	770
Citrus processing	94	168
Mining	191	363
Total industrial	2,229	3,421

[1] Average rate for entire year.

Source: Florida's Water Resources: Report to the Governor of Florida and the 1957 Legislature by the Florida Water Resources Study Commission, Gainesville, Fla., December 1956.

TABLE 6.—*Water use in California* [1]

23 million acre-feet (20 billion gallons per day) of water used in California in 1956
26 million acre-feet (23 billion gallons per day) will probably be used in 1960
31 million acre-feet (28 billion gallons per day) will probably be used in 1970
50 million acre-feet (44 billion gallons per day) for full development

Present annual water requirements in Los Angeles area is 1,134,000 acre-feet (1 billion gallons per day).

Ultimately this area will need 2,670,000 acre-feet per year (2.37 billion gallons per day).

(*b*) *and* (*c*). *Sensitive areas and their projected water requirements*

The relationship between supply and demand is sensitive when the dependable supply is not much greater than the consumptive use. Although the gross supply is a firm amount on the average, the dependable supply varies with the value of the water. The dependable supply can be increased by storage in reservoirs and underground, by control of stream pollution, by development of ground water, and by transfer of surplus water from one area to another. These methods of obtaining successive increments to the dependable supply are increasingly expensive, but the expense may be justified by critical needs.

Among large areas, the most sensitive balances between supply and demand are in the Colorado River Basin, the Great Basin, and the California coastal area. In many Eastern States, however, local factors, such as serious drought or rapid increases in water demands have caused temporary water shortages.

The average long-term "gross supply" of water is assumed to be the same as the average runoff in streams (table 7). This will not change much in the next 25 years. The "estimated dependable supply" is the part of the gross supply that could be developed economically under present conditions. "Gross use" is the total amount of water withdrawn. Some of the gross amount is returned to the source and it may be reused one or more times. Therefore, the amount shown as gross use exceeds the dependable supply in some instances. "Consumptive use" is the amount of water that is incorporated into a manufactured product or evaporated. When water is used consumptively, the dissolved mineral matter in it often is concentrated in the remaining water, whose quality is depreciated. Generally, some water must be used without consuming it so that it can carry off or dilute wastes. Therefore, not all the dependable supply is available for consumptive use.

[1] Source: Max Bookman, California's Water Resources and Plans for Their Development, in Industrial Uses of Water in California, Committee on Research in Water Resources.

TABLE 7.—*Estimated relation between supply and demand in sensitive areas*

[Millions of gallons per day]

Region	Gross supply [1]	Withdrawal use 1955 [1 2]	Estimated dependable supply 1980 [3]	Estimated gross use 1980 [3]	Estimated consumptive use 1980 [3]
Delaware-Hudson	32,000	14,900	24,000	24,880	1,560
Chesapeake	51,000	4,750	12,000	12,610	1,210
Missouri River-Hudson Bay	52,000	23,400	33,000	42,650	18,200
Arkansas-White-Red	90,000	7,590	20,000	19,080	6,890
Western Gulf	52,000	19,800	20,000	29,020	9,440
Colorado River	13,000	16,900	15,000	15,980	9,310
Great Basin	10,000	11,700	9,000	8,730	4,170
South Pacific	64,000	27,000	28,000	26,310	11,300

[1] Circular 398.
[2] Includes some saline water.
[3] Woodward, D. H., 1957, Availability of Water in the United States with Special Reference to Industrial Needs by 1980: Student exercise, Industrial College of the Armed Forces, Washington, D. C.

Not all water shortages arise from an unfavorable ratio between supply and demand. Many result merely from inadequate storage, diversion, pumping, treatment, or distribution works. Reserve capacity is essential in all features of a water-supply system to assure that drought or other temporary shortage of water will not seriously curtail water use.

The amount of water used at any time depends on its availability and cost and on the need for water. Although the water demand in some arid regions does not exceed the dependable supply, more water could be used in those areas if it were available for additional industry and agriculture. The arid and semiarid areas generally are desirable for industry, but lack of water or high cost of water development deters expansion. At some places the amount of irrigable land surpasses the capacity of the water supply.

Sensitive areas are known throughout the country and a description of these and their problems would require many pages. We shall outline a few to indicate where some of the more sensitive areas are and to illustrate the variety of forms taken by water shortages.

Delaware River and Hudson River Basins.—This region is humid and well watered, but dependable local supplies of water are becoming increasingly expensive to obtain or develop. New York City has developed sources as far away as the headwaters of the Delaware River. The water used in New York City is discharged directly to salt water bays, so little of it is reused. To be reused, the waste water would have to be recovered directly from discharge sources.

In the Philadelphia-Camden area, ground-water aquifers receive some recharge from the Delaware River, and the water is poor in quality. Deepening of the ship channel here, which has been proposed, would increase the interchange of water between the stream and the aquifer. Therefore, interest is focused now on the quality of water in the river.

Southeastern United States.—At Savannah, Ga., the pumping of ground water has developed a cone of depression that extends radially more than 20 miles. Near the center of the cone ground-water levels have declined as much as 100 feet. Salty water has not appeared in the wells, but may be moving slowly inland toward them. Outpost wells have been drilled so that forewarning of movement will be available in time to allow preventative steps to be taken before contamination spreads.

The highly permeable aquifers in the coastal areas of Florida, especially near Miami, are subject to salt-water encroachment even where the hydraulic gradient inland from the sea is slight. Contamination can be controlled to some extent by proper location and regulation of drainage canals and by careful construction and control of pumped wells.

Throughout much of Florida's coastal area, conditions permit salt-water contamination of ground water in the coastal lowlands. Most of the ground-water aquifers communicate directly with the sea, and salt water has moved into aquifers tapped by wells in many municipal water-supply systems. In some cases, new well fields or other sources of supply have had to be obtained.

Upper Ohio River Basin.—Drainage water from coal mines acidifies many streams, especially the Monongahela and Allegheny Rivers and their tributaries, and raises the iron and sulfate content of the water to excessive levels.

The temperature of river waters in the Youngstown area is raised greatly where the water is used for industrial cooling and then returned to the river.

Throughout the Ohio River Basin, the rivers receive industrial wastes, including phenols, which depreciate the quality of water and create undesirable tastes and odors.

Kansas.—Excessive amounts of dissolved solids in surface waters are one of the major problems in Kansas. The principal sources of saline waters are in a north-sound band about 150 miles wide across the central part of the State. There, salt-bearing rocks occur from the southern border of the State northward almost to the valley of the South Fork of the Solomon River and eastward about to the confluence of the Saline and Smoky Hill Rivers.

Arkansas-White-Red River Basin.—Wide seasonal and yearly variations in the surface-water supply are characteristic of this region. Without reservoir storage of surface water, only a nominal percent of the gross supply would be available for use. Most of the water supplies that are not fully developed are in the eastern part of the region. In some areas the quality of the water is poor.

Cities in the headwaters of the basins, such as La Junta, Las Animas, Rocky Ford, and Lamar, Colo., have serious water shortages during droughts, and the water at places is poor in quality.

Principal cities in western Oklahoma and parts of Kansas are perennially short of municipal and industrial water because the natural supply is small and because of natural salinity and industrial pollution of the water. The explosive growth of Oklahoma City since 1945 resulted in a serious water shortage during the drought of 1950–57. The shortage was temporarily alleviated by drilling about 70 wells in an alluvial aquifer and 17 wells in a sandstone aquifer. Wells in the alluvium have a productive life expectancy of 90 days. Saline water is produced with oil in the area, and it may be a new source of supply if salt-water conversion becomes feasible. Water in the Arkansas River is saline most of the time from John Martin Reservoir, Colo., to Muskogee, Okla. The average concentration of dissolved solids ranges from 1,660 to 1,720 parts per million, but at times the concentration is more than 5,000 parts per million.

Western gulf area.—The western gulf area drains into the Gulf of Mexico west of the Mississippi Delta. The balance between supply and demand is favorable in the eastern part of the region, but in the western part the demand is approaching the dependable supply. The two principal farming areas, the Rio Grande Valley and the Pecos River Valley, definitely are short of water for irrigation. Many parts of Texas are short of irrigation water, and in the northwest part of the State pumping from wells is depleting the supply faster than it is being replenished.

Pumpage of ground water for irrigation in the High Plains of Texas increased from 1,175,000 acre-feet per year in 1949 to about 5 million in 1954. Recharge is estimated to be about 50,000 acre-feet per year, and the ratio of pumpage to recharge now is about 100 to 1. In this area the city of Amarillo extended its supply lines to new well sites and is studying the possibilities for artificial recharge of ground water.

Dallas and Fort Worth have been short of water in recent years. In 1956 water imported by Dallas from the Red River was so saline that its usefulness was small.

In the Houston area, pumping of ground water has reduced the hydrostatic pressure and allowed the land surface to subside several feet. The structural drainage problems are more critical than the shortage of water.

In southwestern Louisiana heavy draft on ground water for rice irrigation has lowered the water levels and induced some contamination by salty water in the tidal streams.

The Pecos River is slightly saline to very saline throughout nearly all its course. The concentration of dissolved solids ranges from 1,550 parts per million at Puerto de Luna, N. Mex., to 10,700 parts per million near Grand Falls, Tex. The Rio Grande River also is slightly saline at times at some points.

California coastal area.—The California coastal area is the part of California that drains to the Pacific Ocean. The balance between supply and demand is favorable for the area as a whole, with a surplus in the northern part and a shortage in the southern part. Los Angeles and San Francisco discharge large quantities of usable water to the sea in the form of sewage and storm drainage.

In the Long Beach, Santa Ana, Huntington Beach, and Orange County areas, salt water has invaded the shallow ground water aquifer. Shallow ground water far inland is inferior in quality in many places. Very saline waters occur in deep

aquifers in the area. The lower reaches of the Los Angeles and San Gabriel Rivers are contaminated greatly by industrial and other wastes.

Salvage of water and importation from areas of surplus is a potential means of relief for the water-short southern part of the area. The balance between supply and demand in the region as a whole may become critical with increased use and drought conditions.

Missouri River area.—The greatest use of water in this region is for irrigation, and a great increase in this use is predicted. Pollution and lowered quality of water may become serious problems in some areas.

In Denver and the surrounding metropolitan areas, where shortages have occurred, water systems require expansion. Pueblo, Colorado Springs, the United States Air Force Academy, Boulder, Longmont, Loveland, Fort Collins, and many smaller communities are faced with this problem. Available supplies are inadequate to irrigate all available fertile land in Colorado east of the Rockies.

In the High Plains of western Kansas, northeastern Colorado, southeastern Wyoming, and western Nebraska the water is generally good in quality but limited in quantity. In the northern plains of the Dakotas and part of Minnesota, water is generally poor in quality and short in supply, and expansion of use has not been a material factor.

Colorado River and Great Basin.—According to present estimates, demand will equal supply in about 25 years. Consumptive use will be about as great as these regions can support and poor quality of water will be a limiting factor in some localities. Although the supply and demand are not far out of balance, much more water could be used for irrigation and industry if it were available.

In nearly all of Arizona, municipal and industrial water is in short supply during droughts. Water in the southern third of the State is inadequate to meet all irrigation needs. Many cities in this region had water shortages during the recent drought of 1954–57.

3. Bureau of Reclamation

"(*a*) Irrigable acreage in reclamation projects that has gone out of production or is threatened by alkali, other salts, or brackish water generally;"

To the best of our knowledge no irrigable project area has actually gone out of production because of the quality of water applied. There may be instances where quality of water contributed to or accelerated the development of unfavorable soil conditions and in other instances has prevented growing of certain types of non-salt-tolerant crops. In such instances the situation has proved susceptible to modification by dilution and proper management practices or selection of crops. Likewise, there have also been instances where salts in the water in varying degrees have had beneficial effects.

"(*b*) Location and acreage involved in areas where demineralization of brackish water, if economically feasible, might be helpful;"

The development of unfavorable conditions such as restricted drainage is due largely to the application of water to soils possessing unfavorable physical and chemical characteristics. The various interactions, however, are very complex and accordingly the net effect is difficult to predetermine. Based on our present understanding of the situation there are no areas where it can be safely assumed that demineralization of brackish water is a practical solution to this problem. In the final analysis, sustained irrigation is dependent upon getting sufficient water of suitable quality through the soil profile to permit leaching of harmful salts. There may be instances where demineralization would be helpful in this respect.

"(c) Federal investment in irrigation, drainage, or other facilities which is threatened or has been written off as a result of water quality, including Shadehill Dam in South Dakota."

Excluding Shadehill Dam, there is no Federal investment in irrigation, drainage, or other facilities which is threatened or has been written off because of quality of water. With respect to the Shadehill Dam in South Dakota, studies of the feasibility of irrigation development are continuing. A favorable response has been indicated from application of gypsum on the development farmlands. A number of years will be required, however, to determine the feasibility of irrigation. In this instance both unfavorable inherent soil characteristics and poor quality of water appear likely to contribute to unfavorable reactions under irrigation. It should be recognized, however, that reimbursable irrigation costs of the Missouri River Basin project units would not be written

off if the irrigation proves infeasible, but rather that they would be met from other project revenues.

There have been a few instances as in the Moreau, Bad, and part of the White River Basins of South Dakota where preliminary investigations have disclosed that the water quality was of such nature as not to warrant detailed feasibility studies. It is quite likely that more detailed investigation would indicate that soil problems as well would develop.

4. OFFICE OF TERRITORIES

"(*a*) Water problem on St. Thomas, Virgin Islands, with existing and estimated potential demand; and how current and past emergencies have been or are being met:"

For a number of years the Island of St. Thomas, Virgin Islands, has had a difficult water problem. Although the average rainfall is between 40 and 50 inches per year, it is unevenly distributed through the year and rapid runoff, as well as rapid evaporation, causes serious deficiencies for extended periods. There are no substantial flowing streams on the island, nor are usable underground sources of water believed to exist.

Many private homes and certain of the hotels provide their own potable water supplies to a degree through catching rainfall; others rely primarily or entirely upon the city water system, which is supplied by catchments. During dry periods, however, these resources have proved to be inadequate. At such times, it has in the past proved possible to secure emergency assistance upon occasion from the Navy, through the barging of supplemental water supplies from Puerto Rico. This practice, although far from satisfactory, has been followed for a considerable number of years.

During recent years, the demand upon the city water system has increased sharply, due partly to construction of many new tourist facilities, plus several public installations which are substantial water users. The economic basis for St. Thomas is primarily the tourist industry. While residents of the Virgin Islands may have learned to live with occasional water rationing, tourists will not accept it.

These recent increases in requirements have on several occasions made the problem extremely difficult, and required the barging of tremendous quantities of water over extended periods. To avoid dependence upon the Navy, the Virgin Islands government in 1956 purchased a tug and barge which was used on virtually a round-the-clock basis for a period of some weeks during the winter tourist season of 1956–57. Some water was also secured through Navy and commercial barging at that time, but the bulk of the supplemental water was provided through operations of the Government's own tug and barge. By that means a severe water stringency was averted at that time.

The use of the tug and barge, however, has never been considered by the Office of Territories or the Virgin Island government as other than a stopgap measure. Simultaneously, plans have been developed for the installation of water conversion facilities, to be operated by the Virgin Islands Corporation, on a basis whereby the water produced may be sold at cost to the Virgin Islands government, for distribution through its mains.

With respect to existing and estimated potential demand, we rely primarily on the careful study made by the engineering firm of Gibbs & Hill, Inc., in 1956. That study found a present requirement of slightly over 200,000 gallons per day, which it expected would increase to approximately 376,000 gallons per day in 1970. For 1965 we calculate a minimum need of 320,000 gallons per day. The study also found a present installed dependable capacity of only slightly more than 100,000 gallons per day, a present average use deficiency of approximately 110,000 gallons per day, and an anticipated use deficiency by 1964 estimated at 200,000 gallons per day. Thereafter, the use deficiency is expected to increase each year by an additional amount of about 20,000 gallons per day.

"(*b*) Population, resident and tourist, that accentuate water problem on St. Thomas."

The population of Charlotte Amalie St. Thomas, increased from 9,801 in 1940 to 11,469 in 1950. For 1955 Charlotte Amalie's population is estimated at 12,500. Assuming that the recent moderate rate of growth will continue, Charlotte Amalie's population in 1965 may be estimated at approximately 15,000.

At present, approximately 1,600 permanent residents of Charlotte Amalie use water regularly in their residences from the municipal potable water system. It is estimated that this number may increase to 2,000 by 1965.

For purposes of estimating the effect of the tourist population on the water situation in St. Thomas, analysis must be based primarily on the number of tourists arriving by air, since cruise ship visitors and military personnel do not ordinarily stay overnight in St. Thomas.

Following are visitation figures by air, for a 4-year period (fiscal years):

1953	29,000
1954	35,471
1955	37,627
1956	46,267

Figures for visitations by air during the fiscal year 1957 have not yet been authenticated, but there is believed to have been another substantial increase over previous years. The firm of Ballante & Clauss, Inc., which recently completed an airport feasibility study of the Virgin Islands, has estimated that the number of tourists visiting St. Thomas by air will increase to 150,000 per year by 1965.

These recent and projected figures on resident population and tourist visitations tend to bear out in general estimated requirements for water developed in the Gibbs & Hill study.

"(*c*) Alternate plans (summarized) to meet current and future requirements with cost estimates available."

In addition to the proposal for salt water conversion facilities, careful attention and study have been given to other possibilities of developing a potable water supply from other sources. No less than nine possible alternatives are briefly analyzed and summarized by the Gibbs & Hill report, each of them being discarded as either unreliable, unsanitary, or too costly. Among those which have received the most attention are (*a*) expansion of paved catchment area with reservoir storage, (*b*) development of ground water supplies, (*c*) impoundment of surface waters, particularly at Turpentine Run, and (*d*) barging of supplemental supplies from Puerto Rico, the method which has been used during recent years.

The Gibbs & Hill report, on the basis of careful study, concluded that the provision of an additional dependable supply of 200,000 gallons per day from construction of additional catchments and reservoirs would require the paving of approximately 74 acres of catchment area at a capital cost of approximately $9,500,000. While the maintenance cost of such a method would be low, the capital cost alone would result in a relatively high cost per unit (from $27.50 to $6.78 per 1,000 gallons, depending on the extent of usage) and the supply would not be sanitary without filtration and chlorination.

As to ground water, geological considerations predict a generally unfavorable experience from the drilling of wells. Such wells as exist on St. Thomas are not very productive, and the quality of water is in general unsatisfactory for human consumption. In order to leave no possibility unexplored, however the Virgin Islands government has entered into a cooperative agreement with the United States Geological Survey at a cost of $15,000 for test drilling operations. While it is possible that some supplemental supplies may be secured from this source, all the evidence indicates that ground water cannot make a major contribution to the solution of the problem.

With respect to possible impoundment of surfacewaters, the only source ever considered by anyone to have real possibilities is Turpentine Run, which has the largest drainage area on St. Thomas. However, repeated studies through the years have found that impoundment of this stream would fail to supply a reliable supplemental supply, and that the yield in fact would be less than that obtainable from rainfall catchments. There would be high percolation and evaporative losses, and in addition the quality of water would be poor. However, in order to study any unexplored possibilities in this potential source, the Virgin Islands government has entered into a contract with the New York engineering firm of Tippetts, Abbott, McCarthy, and Stratton, at a cost of $34,000, for a complete survey of all rain water possibilities on the island.

The method of barging supplemental water supplies from Puerto Rico is the one which has been used in emergency situations in the past. In cases of extreme emergency it is believed that some water can always be secured from this source. However, such a source is not dependable, being subject to weather conditions, availablility of barges, etc. In addition, it is believed that a reliable source on the island can be developed through a salt water conversion process yielding water at less cost.

During the water shortage of the 1956–57 winter season, water was secured by barge through Navy assistance, through chartered tug and barge, through commercial purchase, and through use of the Virgin Islands government's own tug and barge. Costs from these various methods ranged from $4.80 up to over $14 per 1,000 gallons. The lowest of the barging costs ($4.80 per 1,000 gallons) was that of the Insular government's barge and tug; however, it is not certain that such a comparatively low level of cost could be maintained indefinitely with the equipment on hand, or that such equipment could readily be replaced at the time required and at a reasonable cost.

"(*d*) Potential solutions considered by desalting area water or otherwise, particularly with reference to a utilitarian demonstration plant with multiple-purpose possibilities including augmenting of the power supply for the islands."

As noted above, present proposals call for installation of proven and fully developed water conversion facilities to produce a dependable source of supplemental water for Charlotte Amalie. It is planned that the plant would be constructed and operated by the Virgin Islands Corporation, a wholly owned Federal corporation, and that the facilities also include additional power-generating capacity to meet the growing need for power there. Since the Virgin Islands Corporation now operates the power system on St. Thomas, the additional power from this source can easily be integrated into the existing power operation.

The plant as originally conceived would have a 200,000 gallon output of fresh water per day and a net power output of 1,600 kilowatts. More recent designs (January 1958) would produce 250,000 gallons of water per day and a net power output of 2,337 kilowatts with substantially the same thermal input to the plant. A plant of this type is estimated to cost $2 million complete, including new fuel storage tanks and pipelines for Bunker C fuel oil. The plant could be so arranged that when no fresh water were needed, it would operate as a regular condensing steam electric generating plant. Such a plant would meet the island's water needs until perhaps 1966, assuming the accuracy of the Gibbs & Hill estimates of future needs.

It is estimated that a combined plant could produce electric power for 12 mills per kilowatt-hour, as compared with the present cost of 19 mills, including operation, depreciation, and interest. On the same basis it is estimated that the cost of water produced at a combined facility would be $1.50 per 1,000 gallons delivered to storage at the plant. If interest and depreciation are neglected, the cost of water would be about $0.86 per 1,000 gallons.

Although the estimated cost of potable water produced from such a facility may be high in comparison with normal stateside water costs, its reasonableness should be considered in the light of the critical need for an additional firm water source and the expense now being incurred to bring in supplemental supplies of water.

The increased power needs of St. Thomas are such that it is estimated the full output of this plant could be absorbed by the island power customers within 4 years after its construction. It would not replace any of the existing generating equipment; however, because of its lower cost per kilowatt, it could be used as the base load plant to the limit of its capability, i. e., about 90 percent of the time 24 hours per day.

"(*e*) Summary of any water problems in other territorial areas."

Although the provision of an adequate supply of water has been an occasional problem in other territorial areas, it is not believed that up to the present time it has reached such magnitude in any of them as to be of interest to the committee in terms of its present study of possible demonstration plants for saline water conversion.

In the Territory of Hawaii, local problems of water supply exist in particular areas on several of the islands, including several of the larger ones. It is characteristic of the Hawaiian group that heavy rainfall may be experienced on the north or northeast side of the islands, while on some of them the southern or southwestern side may be characterized by light rainfall. Thus, on the Kona coast of the Island of Hawaii a serious drought has been experienced during the past few months, happily broken a few days ago by heavy rains.

On several of the islands large-scale irrigation works have been built by private capital (chiefly the sugar and pineapple plantations) to bring water from the wet side to the dry side of the island. During the last 2 years, the United States Bureau of Reclamation has conducted a study of the Molokai project, an irrigation project now under construction by the Territorial gov-

ernment involving extensive tunnelling on the island of Molokai. The project here envisaged, however, would have no need to call upon salt water conversion processes. Generally, it is not believed that salt water conversion processes are needed or could compete with conventional processes of diverting surface or underground supplies from surplus water areas to dry areas.

In the Trust Territory of the Pacific Islands, water supplies have generally been secured through some form of catchment. Occasional problems of supply may have been experienced on a local basis, particularly by the indigenes on some of the low islands; however, we know of no particular area which requires possible resort to water conversion methods at this time.

It is our understanding that on some of the smaller low islands in the Pacific used primarily as air bases, involving substantial numbers of stateside personnel for their operation, salt water conversion processes may be in use at this time on a considerable scale. For detailed information on such operations, inquiry should be directed to the administrative agencies having jurisdiction over those particular areas.

Senator ANDERSON. Thank you.

We will recess until 11 o'clock tomorrow morning.

(Thereupon, at 5:02 p. m., the subcommittee was adjourned, to reconvene at 11 a. m., Friday, March 21, 1958.)

SALINE WATER CONVERSION

FRIDAY, MARCH 21, 1958

UNITED STATES SENATE,
SUBCOMMITTEE ON IRRIGATION AND RECLAMATION
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D. C.

The subcommittee met at 11 a. m., pursuant to recess, in room 224, Senate Office Building, Hon. Clifford B. Case presiding.

Present: Senator Case.

Senator CASE. The hearing will resume on Senate Joint Resolution 135 and S. 3370.

At the request of Senator Anderson, I will proceed with the hearing. Senator Anderson is temporarily obligated to be at another group meeting and I am hoping he will be able to come in before we have concluded the hearing this morning.

We will proceed with Mr. Roland L. Coit, of Westinghouse.

Mr. Coit, will you proceed with your statement in your own way.

STATEMENT OF ROLAND L. COIT, ON BEHALF OF WESTINGHOUSE ELECTRIC CO.

Mr. COIT. Senator Case, we are very happy to have an opportunity to present our views on this problem. We find that we are in general agreement with the other manufacturers with regard to the timing of this demonstration plant, which has been proposed.

We feel that the plant should be built and can be built at this time with the technical knowledge which is available from several different manufacturers as was shown yesterday.

We feel we are especially well qualified to make this statement because we have operating experience in the field with units which are larger than the ones which were being discussed yesterday.

We have experience in Kuwait with a plant of a new type, a flash distillation plant which is 2½ million gallons per day capacity.

This plant was erected during last summer and is now in operation. The results from that plant show us that this type of plant has quite a great potential for producing potable water from full-strength sea water.

We are in agreement with the theme yesterday that all of these discussions should be broken into the two categories, brackish water and full-strength sea water.

We feel that flash distillation is one of the more promising ways of producing potable water from full-strength sea water.

The new saline water report for 1957 has a picture of the plants in Kuwait. Those of you who have that can take a look at that now if you like.

I can tell you something about it. For your benefit, Senator, this is an artist's conception of it. The unit shown in the saline water booklet shows three things that look like the United Nations Building. These are evaporator structures and we finally placed in operation four of those. Each of those units has capability of 630,000 gallons per day.

Senator Case. Mr. Coit, for myself, as a layman, and for others who will read these hearings, particularly those who have not much background in these different forms of installations, suppose you tell us what is meant by flash distillation.

Mr. Coit. This is the same thing that Mr. Gardner referred to yesterday, flash distillation or flash evaporation.

The mechanism is that you heat sea water to a temperature of 180° to 200° by steam or some other heat source.

Then you pass it into a chamber which is under vacuum or a pressure lower than the temperature at which you heated the water.

The portion of the water then flashes because of energy exchange and this then is your method of distillation. You condense this vapor which has been flashed and that is your product.

Essentially it is distillation, the thing that is different about it is that the distillation occurs on the droplets rather than on the heated surface.

This, we feel, and have found minimizes the control of the scale problem.

Is that sufficient?

Senator Case. Yes.

Of course, the minimization of the scale problem lends itself to economies, I assume, in the result?

Mr. Coit. Economies in operation and economies in design and stability in continuous operation.

Senator Case. I notice by reference to your statement that you started out on this plant at Kuwait with a plant capable of handling 720 gallons per day, that you went from that to 1 millions gallons per day.

Now, you tell us that your recently completed installation will handle 2½ million gallons?

Mr. Coit. Yes, sir.

Senator Case. What does that experience indicate to the practicability of a plant in the neighborhood of 1 million gallons so far as getting dependable results is concerned in measuring the cost of the operation?

Yesterday we talked quite a bit about plants of 1 million gallons per day capacity as suitable for demonstration plants.

Mr. Coit. I think in our opinion that size plant would enable very accurate calculations to be made of further increases in size.

The reason is that the basic building block or construction unit as you can see there, is a plant of 630,000 gallons per day.

You see, each of those individual plants of which this is one, the building block that we have which is adjustable in size, is 630,000 gallons per day, a complete operating entity.

So if you want to build additional plant capacity you simply line up more of those units.

Senator CASE. Supposing you put up two of those units. Would there be any economy in having the two, other than the administrative overhead?

Mr. COTT. No; just the usual engineering approach that larger units cut engineering cost.

Senator CASE. So far as the plant is concerned, the 630,000-gallon unit is as economical for the process itself as if you had a dozen of them?

Mr. COTT. Yes; that is true. The economies are only in construction and overhead type of costs. It is entirely practical to build this so-called building block in 1 million gallons as well as 630 gallons. It is simply for this operation it was practical to build it in that size. It is interesting to note that these 4 units, which are alined there like boilers, are now being attended by only 1 or 2 men. So, the operating costs are essentially, I mean so far as labor for operating, very small. They are completely automatic.

Senator CASE. What does your experience indicate as to the life of the basic plant?

Mr. COTT. I think it is within the usual design; 20-year life could certainly be achieved. We have units in Kuwait now for about 8 or 9 years of another design, and we feel the life of this unit is longer than those.

Senator CASE. Do you have to replace any part of the unit because of scaling?

Mr. COTT. The scaling problem, we feel, has been very definitely minimized. We have about 4,000 hours' operation on 1 of these units. That is how long it has been since it has been in operation. It appears to be highly successful with regard to scaling.

Senator CASE. What have your operations indicated for cost?

Mr. COTT. They are shown on table I of my prepared statement. Kuwait is a unique area so far as fuel costs are concerned. They are still flaring off gas as we used to in the Southwest some years ago.

So, the fuel cost is essentially zero. You see the various schemes there that I have shown. If we take the basic plant and assign to it no fuel costs, there still remains a cost of 63 cents per thousand gallons, which is just fixed charges. If we combine the production of water with that of power, which is done in Kuwait, the powerplant and the evaporator plant are in the same area, operated by the same staff, that reduces the cost to 37 cents per thousand gallons.

So, I think those numbers at least show us that there is a certain irreducible minimum in the capital charges imposed on this water production; that, even if fuel did not cost anything, these kinds of numbers are with us. These are based on actual charges for the plant, with the plant in operation, and all the charges in that is the analysis.

Senator CASE. Is the water immediately available after treatment to go into service mains?

Mr. COTT. Yes. There is blending or diluting, as was mentioned yesterday, to stretch the water. They have brackish water available about 3,000 or 4,000 parts per million. Some of that is blended to bring the total solids back up to 300 or 400 parts per million.

Senator CASE. Are these plants located so that they are immediately adjacent to the community that the water serves?

Mr. Corr. They are adjacent to the community. The water-distribution scheme there is rather interesting in that they treat water much as we treat fuel oil. Water is distributed not by pipes, but by tank trucks, and each house has a little tank on top, like farm homes used to do, pump the water up and let it run down by gravity into the homes. So, water is very precious there to the people. It is treated much as we treat gasoline or fuel oil.

Senator Case. To evaluate these things from a cost standpoint, I think, we have to keep in mind the availability of the water to the purpose for which it will be used.

For illustrative purposes, let us assume we have a city which is adjacent to the ocean where it could use sea water if it had a practical process, but it does not, so it goes up to the mountain, 15, 20, 25 miles away, and there constructs a reservoir and has to bring the water down to the community.

Sometimes they use a closed flume; sometimes they carry it in an open stream, if they build a filtration plant.

That cost, until the water reaches the city limits, is a cost which enters into the price at which that water can be sold, of course.

You have the distribution cost beyond that. If you have a community which was getting its water from some existing source and has the reservoir cost, the carrying cost to get it to the city limits and, possibly, a filtration plant there; that cost would be eliminated if this plant could be put on the other side of the city, let us say, and pick up the water from the ocean.

When you have figures here of $1.87 or $1.61 for a thousand gallons where you include the fuel cost, do you have any basis for comparing that with the cost that some communities in this country might have for getting their water supply to the city limits?

Mr. Corr. No, sir; I am not familiar with that. These numbers shown, $1.87 and $1.61, should be commented on, I think, in that they are based on importation of oil into an area, like an island area, or something like that.

We have continued our evaluation, using the methods established by the Office of Saline Water and using their fuel cost, and we find $1.13 per thousand gallons, without power production, and 79 cents with power production, which, again, agrees pretty well with the numbers which were shown yesterday, around 80 to 90 cents a thousand gallons. But I am not familiar with those other numbers.

Senator Case. I simply mentioned that point so that, as we think about the practicability of using some form of desalinization for making water available to a community, we ought to keep this in mind, whether or not that community would have a cost over and above distribution costs as a cost of generating the water itself.

Mr. Corr. I think another interesting comparison could be made, that this area has, as I say, brackish water, 3,000 or 4,000 parts per million, and they also have access to the sea, and they chose to go to the sea rather than to the brackish water.

Senator Case. Why?

Mr. Corr. I would say probably because of the need for power. In other words, if once you decide you need power, then the combination of evaporator plant with power is economical, probably, more than trying to combine a powerplant with the ionic process, which makes no use of the waste heat from the powerhouse.

Senator CASE. Have you used flash distillation on brackish water as well as sea water?

Mr. COIT. We have not. We intend to develop that.

Senator CASE. Do you anticipate any particular difficulty in adapting it to brackish waters?

Mr. COIT. Sea water is a predictable thing and brackish water is unpredictable.

I think it would require considerable investigation of chemical aspects of avoiding scaling.

But it is not a completely unknown field in that all the powerhouses around the country, and they are distributed in every area, do evaporate local water for boiler water. So, we have a basic background of information from which to start.

If you can evaporate it with a submerged-tube evaporator, we are convinced you can evaporate it much more easily with flash distillation.

Senator CASE. What difficulties would you see, if any, in developing a demonstration plant for brackish waters, using the flash-distillation method?

Mr. COIT. There would be the scaling problem. That would be the one we would be concerned about; the ability to keep the units in service a long time.

As I say, I think there is technical background in most areas of the country and it is not an unknown field, but one in which there would have to be some engineering study.

Such a plant would be useful in a given area in that it did show that the scale could be controlled.

I think the value of one of these plants would be the fact that, as other people have mentioned, people could come and see it. It is very interesting to see water coming, sea water coming into a plant and drinking water coming out at the other end of a 6-inch pipe running full, that this plant produces.

If you discharge that in an open flume, it is very interesting, I think.

Senator CASE. Are you experiencing an influx of visitors to your plants in Arabia?

Mr. COIT. Yes, it has become a stopover point for people in the area to see these plants. It has been true before and even more so now. There are developments in Israel and places like that that are actively being negotiated now by several manufacturers to use distillation for rather large-scale water production in the whole Middle East area.

Mr. LINEWEAVER. To summarize your view, Mr. Coit, the view of Westinghouse, do you state that the saline-water programs have passed the pilot-plant stage?

Mr. COIT. I would say it has in the field of distillation. In fact, it has before they were organized and they appreciate that, also, that the thing we are proposing is now new, but it is practical and if we are looking for some practical demonstration, then it is our feeling that the technology has advanced such that it should and could be done.

Senator CASE. Do you see any field for a new breakthrough that would thoroughly modify the costs of the operation as you now have it developed?

Mr. COIT. Maybe breakthrough is not the right word, but engineering advances are definitely in the offing.

We are not on the flat part of the cost curve. Things are coming down.

As I mentioned in the statement, as to our own apparatus between 1953 and 1957, in spite of the rising indices, we were able to install this new type plant at 40 percent under the cost of the other plants for evaporating equipment, only.

Senator CASE. In what period of time was that?

Mr. COIT. 1953 to 1957. That was a design change.

In other words, we went from a so-called submerged tube evaporator to this type and that in itself reduced our cost that much.

Senator CASE. Reduced by 40 percent?

Mr. COIT. That is right, to 60 percent.

This change in materials that has been mentioned by other people is a potential large reduction in capital cost. If we can show that lower cost materials can be used economically, then there may well be another large cost reduction.

Senator CASE. Thank you very much, Mr. Coit. That is a very helpful statement.

Your entire prepared statement will appear at this point in the record, to supplement your remarks

Mr. COIT. Thank you.

(The statement referred to follows:)

PREPARED STATEMENT OF ROLAND L. COIT, ON BEHALF OF WESTINGHOUSE ELECTRIC CORP.

We are pleased to have the opportunity to discuss Senate Joint Resolution 135 before the Committee on Interior and Insular affairs.

A. WESTINGHOUSE EXPERIENCE

While we have not participated directly in the saline-water program sponsored by the Congress, we have followed these developments with keen interest. These research programs have been helpful in evaluating the various schemes for providing potable water and have created widespread interest in the purification of saline waters.

Westinghouse has been active in the field of sea-water distillation for many years, having installed a 720,000-gallon-per-day plant in Kuwait, Arabia, in 1950. This installation has been enlarged to 1 million gallons per day and continues to supply all the water requirements of the refinery and personnel of the Kuwait Oil Co.

This installation attracted widespread attention and the ruler of Kuwait ordered a similar Westinghouse plant which was put in service in 1953. While these plants are satisfactory and are in full-time operation, it was apparent that design improvements were needed which would permit large unit capacities (the above installations consisted of multiple plants each of 120,000-gallon-per-day capacity) and reduce operating expenses.

During 1958, Westinghouse placed four multistage flash evaporator plants in operation in Kuwait. These units each produce 630,000 gallons per day of drinking water from high salt content Persian Gulf water. This installation has been in operation for several months and our experience indicates that we have successfully minimized two of the most troublesome problems normally associated with sea-water distillation, scaling and corrosion.

Thus our experience confirms that of many other groups: multiple-stage flash evaporators are today the most practical means of producing large quantities of potable water from full-strength sea water.

B. ECONOMICS

If one grants that flash distillation is a practical method for desalting sea water, it remains to be shown that it is an economic scheme. Distillation plants are installed in areas where fuel costs are appreciable as well as in regions where waste natural gas is available at essentially no cost. An evaluation of the cost of water from the installation in Kuwait was made by J. R. Emmett[1] of the consulting firm of Ewbank & Partners, London, as follows:

TABLE I

Scheme	Fuel cost	Combined with power production	Dollars per thousand gallons
A	None	No	0.63
B	None	Yes	.37
C	[1] Yes	No	1.87
D	[1] Yes	Yes	1.61

[1] Based on oil at $2.40 per barrel.

The above data show that the cost of water produced varies over a wide range depending on the assumptions for fuel costs and the possibilities of combining power production with distillation. It should be noted that the 4-stage design is poorly suited for use with expensive fuel; the fuel cost shown would result in an 8- to 12-stage design.

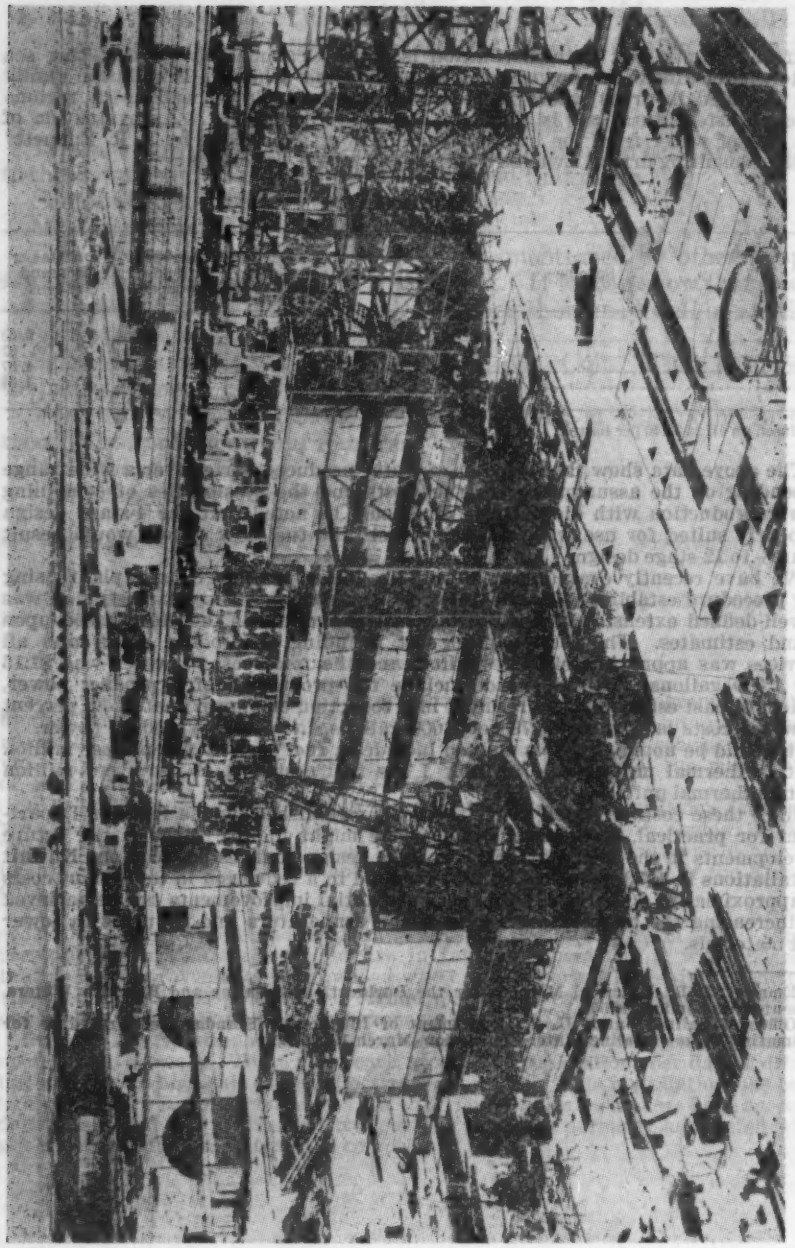
We have recently evaluated a 10 million gallon per day 8-stage plant using the procedure established by the Interior Department.[2] The plant studied was a well-defined extension of our Kuwait experience and is therefore based upon sound estimates. The total capital cost including site, boiler plant, and all services was approximately $18 million, and the total cost of water was $1.13 per 1,000 gallons. This does not include the production of byproduct power, which, in past estimates, has resulted in a reduction of approximately 30 percent in water costs or a value $0.79 per 1,000 gallons, including byproduct power.

It should be noted that this method includes a fuel cost of 25 cents per million British thermal units, while in table I the fuel cost was 47 cents per million British thermal units.

Since these costs are well above the goals established by the Interior Department for practical, economical systems, one might inquire to what the future developments in the field may achieve. The design changes between our Kuwait installations in 1953 and those in 1957 resulted in a reduction in total plant costs of approximately 40 percent. Further substantial improvements can be achieved by increasing the temperature range of the evaporators and by utilizing lower cost materials.

[1] Emmett, J. R., Practical Methods for the Purification of Saline and Brackish Waters, presented in London, 1957.

[2] Office of Saline Water, U. S. Department of Interior, A Standardized Procedure for Estimating Costs of Saline Water Conversion, March 1956.



SUMMARY AND RECOMMENDATIONS

1. Our experience indicates that multistage flash evaporator plants are now economic in many areas and further developments should broaden their areas of application.

2. We would propose that a multistage flash evaporator demonstration plant of moderate size (100,000 to 500,000 gallons per day) be constructed on the coast of the United States or in the Virgin Islands to evaluate costs and to further develop the art of flash evaporation under field conditions. A further advantage of such a demonstration plant would be to acquaint potential users with the practical details of operating such a plant.

Senator CASE. The next witness on our list is Dr. Bertrand A. Landry.

Dr. Landry, we are pleased to have you here.

You may present your statement as you wish; either read it or let it be inserted in the record and develop it informally.

STATEMENT OF BERTRAND A. LANDRY, BATTELLE MEMORIAL INSTITUTE, COLUMBUS, OHIO

Mr. LANDRY. Mr. Chairman, when I wrote the statement I had in mind the bill that is under discussion whereby it was planned to build a large-sized demonstration plant of presumably quite high capacity and high cost.

My statement, therefore, expresses caution and I believe that these hearings so far have demonstrated that perhaps my thinking was right in that we certainly have a number of choices that have been presented to us and it would be very difficult at this time, I believe, for someone, anyone, to pick out one plant for this demonstration, one type of plant, without introducing a measure of arbitrariness in this decision.

As these hearings progress, I have seen the sentiment developed that possibly what should be done is to build a number of what I would prefer to call large size pilot plants, figures of a million gallon per day have been stated, for example.

If we place these plants, a number of them, in various parts of this country where water is needed, we would then obtain data far more reliable than any we have at the present time.

So that from this large-scale experiment, I feel that eventually a full-size demonstration plant which might have 10 to 20 million gallons per day capacity, for example, could be built with full knowledge.

Senator CASE. The point you make is very interesting. It just happens that preceding the opening of this subcommittee hearing this morning, a group of western Senators were meeting on another matter and Senator Anderson of New Mexico, and Senator Kuchel, of California, and I, were discussing this particular point.

Without committing them or without stating this is a final judgment, or anything like that, we did mention that perhaps rather than build one plant which might, as you say, involve a certain arbitrariness in making a decision as to location and as to method, that it might be desirable to have 3 or possibly 4 plants, of possibly small size, but in any event, that would give us more information as to the method or methods, and the suitability for particular water combinations, than if we just selected 1 plant of what we call demonstration size.

Mr. LANDRY. I think that would be very wise.

Senator CASE. I think your suggestion will be given careful consideration when the committee formulates a decision.

Mr. LANDRY. At the present time, at Battelle, we are investigating two processes that have not been mentioned yet. One is the Hickman still, which is in the small pilot scale, and the other concept is solar stills, which we are just beginning to set up.

Both of these processes will, I believe, have their share of applications, but it is too early now to be able to give reliable figures as to cost.

Senator CASE. Yesterday, Dr. Landry, I mentioned having recently read in a newspaper article with reference to the small size of the Hickman still. I believe I obtained permission at that time to place in the record, I have it with me here now, it is an article which appeared in some of the daily papers in the country on the 13th of March 1958, by Tim Smith, with an Associated Press line.

In this article Dr. Hickman describes this household unit as no bigger than an automatic washing machine tailored for householders on coastal lands where supplies of pure water are slim or nonexistent.

The unit can also be used, the doctor says, to purify polluted waters inland.

It is a version of a large commercial unit which Hickman designed for the United States Department of the Interior, which is being planned for test run at Wrightsville Beach in North Carolina.

In the article the statement is made that it is highly automatic and still uses less electricity than a home laundry machine and can turn out 500 gallons of pure water a day.

Manufactured in small quantities it would sell for $1,500, but in mass production its price could be trimmed to $300 a unit, the doctor says.

An electrical pump maintains the still's supply of water. When the tank is full the electric pump shuts off.

Without objection, I would like to place in the record copies of correspondence I have had with Mr. B. F. Childers of Edgemont, S. Dak.

(The letters referred to follow:)

EDGEMONT, S. DAK., *May 4, 1957.*

Senator FRANCIS CASE,
Washington, D. C.

DEAR SENATOR: In reply to your letter of February 27 in regard to the use of gypsum for the removal of insoluble salts.

First let me say gypsum is not a fertilizer but is used in replacement of sodium in a soil that has too much sodium carbonate. Sodium compounds are mostly responsible for these slick spots or hard-pan spots. They occur in both clay or sandy soils and retard the entering of water into the soil. If the accumulation is concentrated enough sodium bicarbonate (black alkali) is formed.

The thing that determines if any irrigation project is to be permanent or not is to keep these salt accumulations moving. The soil is either improving or deteriorating all the time and never standing still.

The whole irrigation picture revolves around the solubilities of the minerals in the soil. Now if you had a good piece of land under irrigation and you used a water containing chlorides, say, sodium chloride, the sodium replaces the calcium in the calcium carbonate (lime), forming sodium carbonate, which is soluble only 7 parts to 100 parts of water and is rated insoluble. The calcium unites with the chlorine forming calcium chloride which is very soluble and if not drained off is very toxic to plants. At any rate, you have lost your lime and you have a very tight soil that does not take water very fast.

By the use of gypsum this process can be reversed. Gypsum is calcium sulfate. The sodium in the sodium carbonate will replace the calcium in the calcium sulfate, forming sodium sulfate which is soluble and can be drained off. The

calcium in the calcium sulfate unites with the carbonate from the sodium carbonate and forms calcium carbonate (lime).

Now you have your lime back and can leach out the sodium sulfate. This will also bring the Ph down to near the neutral point.

This whole process depends on good underground drainage, but it need not be too fast. By this I mean that the water should percolate down and drain off in a lower strata so it does not return to the surface soil by capillary action.

As gypsum is rated insoluble, it dissolves about 600 parts per million parts of water, so it does not do much good to put it on the land unless you intend to flood it. It is better to add it to the incoming irrigation water, all that it will dissolve. This process is relatively slow and is speeded up by carbonic acid formed in the soil.

As to results we have fields that were too alkaline to produce any edible grasses that are now producing up around 3 tons of alfalfa hay on the first cutting.

If you could have time on one of your trips out here, I would be glad to show you just what we are doing and a little later in the summer, say, in June, you could see the results. If you should come, let me know ahead of time so I can be on hand or I could meet you somewhere.

As to the Shade Hill project, I would have to know the composition of the irrigation water and the kind of salts in the soil and the drainage.

This is the first I have ever written about this and the idea is not original with me. Dr. Helgard, who died in 1916, was the first to investigate alkali salts. The United States Regional Salinity Laboratory has done quite a bit of work on it.

If I can be of further service, please feel free to call on me.

Yours truly,

B. F. CHILDERS.

WASHINGTON, D. C., *June 6, 1957.*

Mr. B. F. CHILDERS,
Edgemont, S. Dak.

DEAR BERT: Thank you very much for your long and interesting letter describ- your operation and giving details on chemical changes involved in the use of gypsum.

It does sound as if your soil and water problems are tied up with an excess of sodium and if it works in your area it may well be that it would be equally good in the Shadehill area. The problem there appears to be an excess of sodium ions in the water in the dam, which when used on the soils in that area, bring about the compacting effect.

The information you have given me will be passed along to those working on the Shadehill problem and I'm sure it will prove interesting and of value.

When I get into the Edgemont area I shall keep your kind invitation to view your operation in mind and if time and circumstances permit, I would very much like to look over farm.

With best wishes to you and Mrs. Childers, I am,

Sincerely yours,

FRANCIS CASE.
Senator from South Dakota.

Senator CASE. Is that an accurate description of the Hickman still you have in mind?

Mr. LANDRY. I have not seen this particular unit.

Senator CASE. What would you say about the practicability of the Hickman still for one of the methods that might be explored with the pilot plant.

Mr. LANDRY. The Hickman still is a component part really of the vapor complex cycle. In this cycle sea water is evaporated by the condensation of fresh water produced by the evaporation of sea water.

It sounds like perpetual motion and it almost is except that there are inevitable heat losses to the surroundings and also to operate with practical areas for heat transfer the temperature of the condensing water has to be slightly higher than the temperature of the evaporating water from the sea water.

This means that a certain amount of compression work has to be done to raise the pressure and temperature of the condensing steam so that heat will transfer from it to the evaporating sea water.

Under these conditions, if one refers to simple distillation, the efficiency is, of course, many, many times greater.

Of course, I want to say right here that none of the processes we have discussed so far involve simple distillation.

Multiple effects are always used of some kind or other. But this is a multieffect process of which there are a great many more multi-effects than there are used.

Now, in order to minimize further the area for heat transfer, Dr. Hickman has conceived an apparatus which is a rotating device so that the water or the condensing steam transfers its heat through this rotating device.

In so doing, the thickness of the film, the inevitable film of water which is on these surfaces because of the rotation, this film is reduced considerably in thickness, so that the heat transfer rates are several times what you would expect in stationary equipment.

It just makes it possible to decrease the amount of power required to compress the condensing steam, assuming that the amount of surface is the same as it would be in the ordinary type of still.

Senator CASE. The time I saw Dr. Hickman demonstrate his initial plant in Boston, the thing that impressed itself upon me when he was explaining the thin film of water, was that he compared it to the film of water that is exploded in steam when our mothers in years gone by used to touch their finger to the tongue and put it on sadirons to determine whether or not the iron was hot enough.

He explained the water went into steam much more rapidly. He may have oversimplified it for us.

Mr. LANDRY. It is true that the heat transfer rates that he has gotten in the laboratory are very much higher.

Now, in passing to a larger size, it has not permitted the results to follow the extrapolated curves. Our research is to investigate to find out why. There is no reason why the apparatus of larger size should not behave as of smaller size.

But one must understand better that the process is.

Senator CASE. Dr. Landry, have you completed your statement?

Mr. LANDRY. Unless you have some questions, Senator Case.

Senator CASE. I was intending to ask you this question: Dr. Landry, we have been talking about the Hickman still, somewhat. Would you care to make some comment about your suggestion that you are investigating solar distillation; tell us a little bit about that and its possible utilization; how far you are along in your research on that?

Mr. LANDRY. The research on that, Senator, has not started yet. The contract has just recently been signed. The Florida station where this is going to be done is just now being arranged for these tests. The big problem there is one of principle. Should a solar still be insulated from the ground, or should it be in good contact with Mother Earth?

There are arguments on both sides. So, we are going to instrument these stills very completely, both above and below ground, to decide once and for all, we hope, this question of principle. At the

same time, we will get data on the operation of these stills, and our contract calls for making all possible improvements in their efficiency and for lowering their cost.

Senator CASE. What stage would you say you are in as far as research is concerned?

Mr. LANDRY. We are at the half of 1 percent stage, sir. We are just starting.

Senator CASE. What are the theoretical economies or advantages which attract you to research in this field?

Mr. LANDRY. Well, solar energy is free. All the processes that have been discussed so far at this table involve an expenditure of energy in the form of mineral fuels or electricity and so on, which is made from mineral fuels. Now, the time will come when our fuels will be very precious, very expensive. By that time we will still need water and energy.

The sun may be the sole remaining source of such energy. Although this source of energy is inexhaustible, at least it will last as long as life exists; yet the fact that it is not a steady, but a cycling, source and the fact that it is diffused, not highly concentrated in its natural occurrence, means that the equipment to utilize this is rather expensive. So that we are not fighting fuel costs here, but we are fighting equipment costs.

I believe, sir, that the time to prepare for these eventualities is when you are wealthy. I consider this country to be at this time a wealthy country, but, if we are to wait very long until we become poor like many countries are, we will no longer be able to afford to put up expensive equipment to utilize a free source of energy.

That is true, sir, at the present time. There are countries which are desperately lacking water who cannot afford to purchase the fuel required to make this water and cannot afford to purchase even the equipment required to utilize solar energy.

Senator CASE. Is this contract to which you referred with the Office of Saline Water in the Department of the Interior?

Mr. LANDRY. Yes.

Senator CASE. Thank you very much, Dr. Landry, for coming here. Your prepared statement will be printed in full.

Mr. LANDRY. Thank you.

Senator CASE. Without objection, following Dr. Landry's formal statement I will place in the record the newspaper article concerning the Hickman process, to which I have referred several times.

(The prepared statement of Mr. Landry and the article submitted by Senator Case are as follows:)

PREPARED STATEMENT OF BERTRAND A. LANDRY, BATTELLE MEMORIAL INSTITUTE, COLUMBUS, OHIO

At the present time, Battelle Memorial Institute is investigating for the Department of the Interior, at the pilot-plant scale, a Badger-Hickman still for demineralizing sea water. Also, we have just started to prepare to erect pilot-plant units of solar stills in Florida. In both of these studies, the aim is to determine present performance and to devise means of improving this performance, with the objective of minimizing total unit costs in producing fresh water from saline water. It is not possible at this time to predict when final reliable figures of costs will be available from these pilot-plant studies; certainly, a period longer than 6 months from the present date will be required.

23642—58——10

I was interested in learning that consideration is being given to three possible sites for the establishment of a full-scale plant for saline-water conversion.

It is my belief that, before a decision is made to use a saline-water-conversion process at any of these three sites, a thorough engineering-economic study should be made to determine the cost of marginal water at the site, together with reliable estimates of the cost of marginal electrical power, fuels, and labor. The study should also disclose the type of utilization envisaged for the additional amount of water that is being planned and the market value of that water.

When these facts and figures are available, it should be possible to select the most economical source of water and to select the size of plant whose output would have the indicated market value, if this market value is high enough.

It may very well turn out for some locations that saline-water conversion will be indicated, but, at the present time, it would be impossible to include in the cost estimates, to reach such a decision, the two types of plants that we are investigating, since total unit-conversion costs are not yet available for them.

I sympathize with the concern of the subcommittee to proceed as rapidly as possible with a full-scale demonstration of saline-water conversion in areas needing water. I believe that this step should be made as soon as possible, but I also believe that not enough information is available at the present time to make the wisest choice so far as saline-water-conversion processes are concerned. Furthermore, the choice of the initial site should be made with the greatest care and only after a thorough investigation has shown that marginal water costs are greater than, or at least equal to, saline-water-conversion costs, and that the use that is made of the water produced is economically justified.

Household Salt Water Purifier Developed

(By Tim Smith)

Rochester, N. Y.—The white-haired scientist waited for the ticking of the small, square machine to stop. Then, from a glass jar which was connected to the machine by tubing, he drew a glass of clear, odorless fluid and drank it.

Dr. Kenneth C. D. Hickman smacked his lips, "Not bad."

The fluid was plain water which a short time before had entered the machine as heavy brine. It has been purified in a vapor-compression still Dr. Hickman designed.

No bigger than an automatic washing machine, the unit, as yet unnamed, is tailored for householders on coastal lands where supplies of pure water are slim or nonexistent.

The unit can also be used, the doctor says, to purify polluted waters inland.

HOUSEHOLD VERSION

It is a "baby" version of a large, commercial unit, which Hickman designed for the United States Department of Interior. The Department is planning a test run for this in the near future at Wrightsville Beach, N. C.

The little unit was built in a laboratory owned by Aqua Stills, Inc., a Rochester research company established to develop the process. Hickman is vice president of the company.

Entirely automatic, the still uses less electricity than a home laundry machine and can turn out 500 gallons of pure water a day, Hickman says, about 100 more than the daily requirements of the average family.

Hickman says plans are under way to put the little still into production within a year.

Manufactured in small quantities, it will sell for about $1,500 but in mass production its price could be trimmed to $300 a unit, the doctor says.

COMPLETELY AUTOMATIC

An electrical pump maintains the still's supply of water. Inside, the impure water is passed through heat exchangers, rapidly whirling cylinders, changed to steam, condensed back to water and finally run into a storage tank.

When the tank is full, the electrical pump shuts off. When the purified water is used, the pump starts ticking again to replace the amount drawn off.

Two engineers from the Interior Department's Office of Saline Water recently inspected the machine and called it the most promising of several water-conversion processes now under departmental study.

Hickman expects the unit to find immediate use in nations around the Baltic Sea, in the Caribbean Islands and along the United States Pacific coast, all areas in acute need of good water supplies.

Senator CASE. The next witness is Mr. A. J. Larrecq, of Power Generators, Trenton, N. J., with his associates.

Mr. LINEWEAVER. Mr. Brater and Mr. Ruby, of General Motors, and Mr. Bernhardt, of Allis Chalmers.

Senator CASE. Please give your names.

STATEMENTS OF A. J. LARRECQ, PRESIDENT, POWER GENERATORS, INC., TRENTON, N. J.; ERIC R. BRATER, ASSISTANT CHIEF ENGINEER, CLEVELAND DIESEL ENGINE DIVISION, GENERAL MOTORS CORP., CLEVELAND, OHIO; AND PAUL POLLOCK, ALLIS-CHALMERS CORP., MIWAUKEE, WIS.

Mr. LARRECQ. My name is Larrecq, A. J. Larrecq, president of Power Generators, Trenton, N. J.

To my right is Mr. Eric Brater, assistant chief engineer, Cleveland Diesel Division, General Motors Corp.

To my far right, Mr. Paul Pollock, of the Allis-Chalmers Corp. in Wilwaukee, Wis.

I have drafted a statement, Mr. Chairman, if you will permit me to refer to it.

We have a few props. I do not have the statement typed, so if you will permit me I would like to read from it, sir.

Senator CASE. You may proceed as you wish.

Mr. LARRECQ. Mr. Chairman, naturally, I want to express appreciation for this opportunity of attending this hearing. I think it is well known that the General Motors Corp. has been in the compression-distillation business for many years, having supplied most of the vapor-steam compressors used on compression-distillation stills purchased by the Armed Forces during World War II, I believe some 16,000 in number.

The Allis-Chalmers Co. has been building steam condensers since 1860, and are in the business of moving water in large quantities and transferring heat in large quantities as being special machinery builders such as may be required in large-scale saline distillation.

Before commenting on the bills, I would like to take note of some of the testimony that has been presented here up to this time.

I have in my hand, Mr. Chairman, a standardized procedure for estimating cost of saline-water conversion.

Senator CASE. By whom was that prepared?

Mr. LARRECQ. That was prepared by the Office of Saline Water.

On page 4 of this adjusted procedure is a suggested cost of fuel of 25 cents per million B. t. u.

I wish to introduce a note of caution because I believe that the costs of water that have been talked about may very well be based upon this assumption which is grossly unrealistic.

This would correspond to a cost of Bunker C oil of approximately $1.25 a barrel. I have a letter here from Mayor Doyle, of the city of San Diego, in which he calls attention to the fact that pipeline delivery of bunker C fuel oil is $2.91 a barrel.

It is indicated that under distress conditions, with a new bunkerage capacity being installed in San Diego, that the lowest fuel cost that

can be anticipated in the immediate future is approximately $2.50 a barrel; that is, twice that which is assumed in the discussion based upon this suggested procedure for the calculation of cost.

Senator CASE. Of course, Mr. Larrecq, I do not know whether the representatives of various companies that have been testifying as to cost figures for their particular plant or method utilized the figure suggested in that publication by the Office of Saline Water.

It may be that some of the estimates of possible processes have, if produced by OSW, but I do not believe that applies to the statements of people who have been speaking of a particular plant which they were talking about.

Mr. LARRECQ. Mr. Chairman, I was curious about that point and I inquired of the 2 witnesses that were here yesterday that mentioned 88 cents water.

Unless I did not hear them correctly, I understand that that figure is based upon this cost of water.

Senator CASE. I think there are some of the witnesses in the room who previously testified and I hope they will take note of what Mr. Larrecq is saying and supplement whatever you may have said with an appropriate comment so that the committee will not be misled in any respect as to the validity of the fuel figure that was used in the cost estimate suggested.

Mr. LARRECQ. I would further suggest, if I may, Mr. Chairman, that the same question be put to Dr. Badger, who I believe indicated a cost of product of something of the order of 40 cents. It is rather important, Mr. Chairman, I believe you would agree, that in comparing the cost of potable water that might be generated by desalinization with the cost of Feather River water, that we should have the same terms of reference.

Would it be proper for me to also introduce this note of caution, that the history of fuel prices is an upward trend. I believe reference to the latest issue of Motorship will indicate that world prices are quite substantially in excess of that which we are discussing here even under the most optimistic conditions and with the increasing fractionization of crude oil, the cost of even bunker C fuel oil will increase.

If we talk of multieffect evaporator systems wherein the cost of fuel is a large factor, we must prognosticate an increasing cost of product if we are to take note of the history of fuel costs in the past, I therefore feel it pertinent, Mr. Chairman, to call attention to this possible, I do not wish to use the word "illusion," but I cannot think of a better term regarding what one can realistically produce water for.

I have just returned from a session with the principal parties in the Water Resources Department of the State of California and I wish to echo a sentiment that they expressed to me, that is that they are grossly confused by the great variety of statements which upon closer inspection turn out to be a bit different than on first impression.

Senator CASE. The acting chairman is going to suggest that the members of the committee staff take note of what Mr. Larrecq has said and make contact with the people who have testified and get some identification of the factors used in this cost item so that information will be specifically available for the committee in its executive considerations.

Mr. LARRECQ. Might I also, as a result of testimony presented to this meeting and in echoing your own point, it is estimated that

Feather River water will be available at 10 cents a thousand gallons at an elevation of 3,000 feet.

If one takes account of the cost of pumping potable water from sea level to the likely sources of use, one is rather astonished at what it costs to pump water. It might be in excess of 10 cents a thousand gallons.

Senator CASE. Why do you direct this particularly to California and Feather River water?

Mr. LARRECQ. Because I happen to have authoritative information in this area. It would not necessarily apply elsewhere.

It is, I think, pertinent to take account of the fact that when one compares the cost of water from one source, that the terms of reference should be comparable.

Might I focus attention on the situation existent in California as I have been able to ascertain within the last few weeks?

The city of San Diego is borrowing from the city of Los Angeles 25 million gallons per day. This would imply that the city of Los Angeles, despite the fact that it is growing at the rate of one Salt Lake City every year, presently is not the sore spot, that is, San Diego is living on borrowed time.

This, you might say, demand note of 25 million gallons per day can be, should I say, called on the city of San Diego at any time, considering the rapidly increasing population in the county of Los Angeles.

Therefore, it is a very pertinent and live subject in this city of San Diego, so much so that the mayor has appointed a very fine advisory committee of eminent scientists to judge the various systems.

They have concluded that the price of potable water in excess of 45 cents per thousand gallons would be an upper limit, considering the fact that the small user today is paying something of the order of 20 cents a thousand gallon.

Senator CASE. You mean that that is what it averages out?

Mr. LARRECQ. I have seen bills that are sent to individuals, small-house holders and that is what they are now paying.

Now, an increase of 15 cents a thousand gallons is being made effective in April. A curious thing, Mr. Chairman, I was informed that the history of water consumption in California by municipalities shows no marked decrease in consumption with increasing cost, but, nevertheless, as of now, the responsible people in the city of San Diego are looking for 45 cents per thousand gallons of water.

Senator CASE. If you found that the average water bill averages out at the present time to a cost of 20 cents per thousand gallons and they are contemplating an increase of 15 cents, that would indicate there must be some demand for water if there is to be an increase of that large a proportion to the present base price.

Mr. LARRECQ. Mr. Chairman, I do not think there is any question but what there is an increase in demand of each of the California cities, but hanging over the head of the city of San Diego is the sword of Damocles with 45 million gallons per day written into it and they have to get ready to produce water by some means.

I think perhaps that is a point where one might focus their attention with respect to a particular, shall we say, set of cost conditions, fuel costs, labor costs, comparative water costs.

Senator CASE. Are you suggesting that the Feather River water at an elevation of 3,000 feet is the answer to the San Diego water problem?

Mr. LARRECQ. I think it would be nearer the mark, Mr. Chairman, to indicate the improbability of every matching Feather River water by a desalinization plant at any time if one puts in the pumping costs.

Senator CASE. Of course, we are concerned with communities which do not have Feather River water available. What is your suggestion there?

Mr. LARRECQ. My suggestion is that plants such as I will describe today, permitting incremental increases in production up to the amount necessary, should be immediately constructed, not only for San Diego, but other communities, like Malibu, Avalon, to mention a few, wherein a similar situation exists, but as of the moment one might put on the label "Interim" so far as the city of San Diego is concerned.

So far as Malibu is concerned, and Avalon, it may very well be a permanent solution because the cost of diverting the Feather River water over the Santo Monica Mountains may, and I have seen some preliminary estimates, may very well add up to the cost of water as we think, sir, we might be able to produce it.

Senator CASE. From what?

Mr. LARRECQ. From sea water.

Senator CASE. Let us have your direct testimony, then, on the method that you suggest for the possible desalinization of sea water.

Mr. LINEWEAVER. Mr. Chairman, I think the record should show that there are some problems with respect to the Feather River development that have not been solved in California which may be surmountable or may be insurmountable.

Mr. LARRECQ. You are possibly referring to the county of origin.

Mr. LINEWEAVER. To the county of origin controversy and financing.

Mr. LARRECQ. I think it is proper that that should be taken note of, but, nevertheless, the possibility of getting cheap water in great abundance is existent by this means.

Well, sir, I shall forget my notes and tell you about some researches that we have lately undertaken and some work that we are presently undertaking in cooperation with General Motors and Allis-Chalmers, which is summarized in our report 1522.

If I may make reference to the charts I have brought along, I believe I can indicate to you, Mr. Chairman, and to the knowledgeable people that are present, some of the salient points.

Senator CASE. I trust you will. It is now 12:20 and I have a commitment at 12:30. I do not want to cut you off and would ask you to keep in mind this hearing is primarily a hearing on the problem of methods for desalinization of water, either sea water or brackish water, and the Feather River water problem, while it may be the concern of the Committee on Interior and Insular Affairs, is not exactly the problem of this subcommittee, or this hearing.

Mr. LARRECQ. Would you permit me to make this point, however, that the target that one might have to shoot at might very well be of the order of 45 cents a thousand gallons in order to be of interest.

Senator CASE. If you can suggest how you expect to do that with a method of treating sea water, I am very sure it will be of value to the committee.

Mr. LARRECQ. Fine.

The witness who preceded me pointed out the immense importance of obtaining high heat transfer coefficients, also operating with low-temperature difference in order to reduce the power.

I have here a large photograph of a heat transfer surface which is not unlike what has been noted before in many commercial installations, except instead of the salt water being outside the tubes, it is inside the tubes and runs down inside these tubes.

Our basic heat transfer coefficient with fresh water exceeded 1,500 B. t. u. per square foot per degree Fahrenheit per hour with a temperature difference of 3° F.

This is a problem that brought forth the temperature difference that characterizes the so-called natural circulation evaporator condenser such as we have already built and tested for the Navy.

The power that is required to cause this particular research circulation is approximately 15 percent more than characterizes, you might say, a conventional natural circulation type of evaporator condenser, therefore the natural power is reduced by one-third.

Accordingly, the plant, sir, that you see here at my left, will require one-third the power of any three-stage suggested plant except that suggested by Dr. Hickman.

I believe that we will presently be able to demonstrate heat transfer coefficients very nearly approaching those of Dr. Hickman because this particular test section is 5 feet long, whereas the section employed in this unit here will be 15 feet long.

Now, Professor Howe, of the University of California, will give us official validation of these numbers. The calculated energy consumption for this plant, including all the pumping losses, sir, is 33 kilowatts per thousand gallons.

At $2.50 a barrel, and using the new General Motors prime mover, such as is used on the steamship *Patterson*, this comes to a fuel cost of 16.5 per thousand gallons of product undiluted.

I believe, sir, that this is a hard number to beat and it opens up the possibility of 45 cents water in a manner I shall describe subsequently.

Senator CASE. Do you think that the Office of Saline Water figure of 25 cents was too high?

Mr. LARRECQ. Twenty-five cents for the fuel cost of a million B. t. u.?

Senator CASE. What is 16.5, how many B. t. u. is that?

Mr. LARRECQ. That is 1,000 gallons.

So the irreducible cost of product is 16.5 per 1,000 gallons, using sea water.

If we used brackish water, because we are only using a temperature difference of 3° F. plus 1° rise for salinity and you get an increase in production of approximately 20 percent, which is being the commensurate reduction in fuel cost, using brackish water.

May I describe that plant a little bit?

We are moving toward taking fixed price turnkey tracts with this equipment in the near future. Our basic thesis is to use equipments already employed in central stations or in the marine world.

Mr. Brater will describe the General Motors free piston gasifier turbine combination such as was purchased by the Maritime Commission for the steamship *Patterson* and which has been employed in various parts of the world for 20 years.

It is a reliable robust piece of equipment of known characteristics and it is of extremely high efficiency. It is not sufficient, Mr. Chairman, to stretch our imagination on the remainder of the plant if we lose out on the efficiency of converting fuel oil into mechanical power.

Here you see an Allis-Chalmers, or it could be a Carrier Corp. actual floor compressor of which approximately 10,000 have been built for the Atomic Energy Commission.

The machinery which you see here is a going institution on which we can get turnkey fixed-price contracts. We know what they are going to do over a period of 20, 30, 40 years.

It therefore becomes a question of what do we do over here.

Might I turn your attention to that?

Senator CASE. I notice on your chart there you have the 2½-million-per-day plant. These units you just referred to, are they available in size that would be suitable for a million-gallon-a-day plant?

Mr. LARRECQ. I don't believe so because we can produce this plant for about the same cost as the million-gallon-per-day plant. We are now negotiating with parties in Israel for the utilization of this plant.

The whole conception here is to standardize, reduce cost, have a basic building block that can be used in any part of the world.

Now, the building blocks that I am going to show you are two kinds. This is a Waltz engineering feed water heater such as are procurable off the shelf, as Dr. Badger says. It is a commercial item. Its function is to raise sea water from the temperature of 40° to 60° to a temperature of 180° F.

There is nothing unusual about that. The only thing we need to focus our mind on its this evaporator condenser.

I am going to call this a water refinery actually because what I am going to show you here is very much like you will find in most refineries in the world today.

I have here a reduced size evaporator condenser. It is approximately 11½ feet in diameter and it is about 85 feet high, about the size of a cement kiln such as the Allis-Chalmers people have been shipping all over the world.

Inside this container, as in a refinery, there is a stackup, four indicated here, of heat transfer surfaces such as you see there.

That is one-third size in the flesh.

Imagine that 15 feet high and you have 4 stacked up one on the other. There is nothing unusual about this type of heat-transfer-surface because many evaporators all over the world are exactly the same in outside appearance.

The only thing we have done is to turn it inside out and in doing that we may very well have made a technical breakthrough that will put a new advantage point on this subject matter of desalinization.

Might I say again that this is the same material that is used in the Allis-Chalmers condenser. The same applies for these tube sheets.

We have calculated our cost on those expensive materials that you can lay your hands on, Cooper nickel; this is the best material for steam condensers used in various parts of the United States of which there is an average life history of 22 years.

Our economic analysis based on the suggested procedure by the Office of Saline Water conversion, except, sir, that we have put in the actual cost of fuel oil, not the anticipated cost of fuel oil.

On the basis of a so-called projected cost of fuel oil our price is approximately 45 cents a thousand gallons.

Now, this figure was arrived at, sir, by getting fixed prices, cost estimates from the most reputable firms in the United States. They were bound by their costs.

So these costs were not arrived at, you might say, by picking numbers out of the air.

Now, might I call attention to one other thing. I have here a schematic diagram. I am not going to burden you with the niceties except to say that we are sort of kinfolk with Dr. Badger. There is a difference like the difference between the two Badger families you probably met in the 17th century, but there is a slight difference.

Dr. Badger says "I will face up to the problem of salt deposition by acid scaling, by using acid control." Mother Nature said you can sidestep that issue if you will evaporate between 125° and 150° F.

You can substantially sidestep and this can be proved by Office of Saline Water reports.

Our objective, therefore, is to evaporate at low temperature such that the incidence of scale is at a minimum. To do this economically with an eight-stage cascade evaporator requires operation at 3° temperature difference which requires a revolutionary new kind of heat transfer surface.

Maybe we have one, maybe somebody else has another, but you can't escape 3° F.

Dr. Hickman will show you one way to do it, we will pick another.

We have 1 steam compressor bridging all 8 of these evaporators-condensers. It means that instead of writing compression distillation with a large C and making it all machinery—you see, the machinery set is rather small compared to the heat transfer set.

Now, we have Cooper Nickel. You will see that one-half of the cost of this plant is in these units. If we were successful in using aluminum we would reduce the cost from $1.50 per gallons per day to $1 gallons per day.

We are going to put the Aluminum Company of America to work on that right away.

The Allis-Chalmers have built two condensers using aluminum. But there are other possibilities. I have said that we have based our economic analysis on a heat transfer coefficient of 1,000.

We have measured heat transfer coefficients up to 1,700. We are not going to be satisfied until we get to 2,500.

At some point, 6 months from now, after we have installed units on the California coast and tested them under actual installation conditions, under actual salt conditions, and we expect to have one in operation soon, we will know possibly what is the history of heat transfer coefficient over a 60-day period.

It may be that at that time we will have courage to cut the heights of these things down, instead of having 4 stack sections we will have 3 and possibly 2.

Let me show you what a 20-million-gallon-per-day plant might look like. It is built up of the same fundamental building blocks. I do not know that it is too clear.

Senator CASE. If you reduce that from the 4 stacks to 3 will you increase the quantity of water that will pass through in a given period of time?

Mr. LARRECQ. The eye of the needle, sir, is right here. We cannot pass any more water than this will pass.

Senator CASE. That is the compressor?

Mr. LARRECQ. That is right. You might ask why should you not go to a larger compressor, our theory is to have blocks small enough, easily transportable, that can be used in small communities.

You mention South Dakota. I can mention Ardmore, Pa. I will say this, we need water in Ardmore, Pa., more than they need it in Los Angeles. We are paying 75 cents a thousand gallons and there are a lot of times when I can't flush the toilet. That is an unsanitary condition.

If we can use these units to take dirty Delaware River water and the pure condensate, distillate, and irrigate it, we would be very happy indeed.

The use of these plants is universal. There are 300 of these units being built in various parts of the world.

This is a revolutionary new conception. They can be used on locomotives, ships, saline water conversion, standby, and emergency service generating plants.

Our idea is the General Motors thesis, standardization, get the cost down, easily transportable units, used in multiples in any part of the world.

Here is the buildup, 20 million gallon per day, the same spare parts, same operations. You can have the automation of operation.

I think if Mr. Brater can be given 10 minutes to tell you how it is possible to convert the dirtiest, cheapest fuel oil in any part of the world into the kind of mechanical motion that will turn this big pinwheel, you will have an appreciation of the fact that we have come a long ways toward doing the kind of job which is done in the central station where you have it unitized.

Will you give Mr. Brater 10 minutes.

Senator CASE. Are you going to explain a little more, yourself, about the means used to turn the process inside out?

Mr. LARRECQ. I will be very pleased to.

Senator CASE. Will you proceed.

Mr. LARRECQ. Whatever I have to say here is the product of many minds. I want to give testimony to the effect that Dr. Hickman deserves an awful lot of credit for opening our eyes to the possibility of operating at 3° F.

In this respect the Office of Saline Water deserves a lot of credit. We have asked ourselves how can we do the same thing in another way.

No doubt, as a result of this discussion other people will ask the same question. I am sure there are more ways than one to do it.

I think the folks here, knowledgeable, in the art, will recognize the following: Those that have studied Dr. Hickman's report probably ask themselves why the high heat transfer coefficient.

Dr. Hickman's suggestion is that there are vortexes created in the thin film that transport heat from the hot surfaces to the evaporating film. I think this is right.

When I was a young engineer with General Electric Co., I experimented in exactly this. It is the invention of a French abbe who built a personal refrigeration unit. We will have a head of water 3 or 4 feet a second.

As the water proceeds downward under the acceleration of gravity, the velocity increasing, the tubes sort of tend to be characterized by a rain type of flow. If, however, there is a continuous rotation of the flow there is created a vortex such that the fluid is at all times held against the surface.

By having a recirculation of the water in the ratio of 10 pounds of recirculated feed for every pound of feed that is evaporated it is therefore possible to get heat transfer coefficient such as has been reported to the Office of Saline Water Conversion by Yale University.

As a matter of fact, we are exceeding the Yale University results by approximately 50 percent.

I believe if we go to the longer tubes we will come very near Hickman's result. So inside this tube there is a vortex within which steam is accumulated and this vortex flow issues from the bottom of these tubes and hits a pan of water so-called and it is rather surprising how effective that is in evaporating steam from the water.

We have successive stages. Why? To avoid the high terminal velocity that otherwise might be induced by the acceleration of gravity we in effect start live over again every 15 feet.

We have, therefore, limiting velocities and the possibilities of the tube drying out and the deposition of salt resulting therefrom is thereby completely eliminated.

But seeing is believing. Come to Trenton, we will show you this in operation.

There is a thermometer at the top. It reads exactly the same temperature of feed as the thermometer at the bottom indicating isothermal evaporation.

Without isothermal evaporation that is the same temperature evaporation top and bottom, and I want to illustrate that this way and I think this can be very clear:

Let us say this is the tube. On this side I have a temperature of condensation, let us say it is 150° F. This tube is 15 feet long. The tube may be equally effective; it is desirable that the temperature in this tube be full length of tube. It happens to be a 30-foot tube, will be 154, 1° representing the elevation of the boiling point.

If we don't have 34,000 milligrams per liter, this figure then becomes not 154 but 153.

Therefore, the compressor up here in the case of brackish water only has to produce a thermal potential analogus to an electrical potential of 3° F. to generate the full gallonage per day.

With sea water this becomes 4° F., 25 percent more power or conversely for the same power we can get 25 percent more production if we have, let us say, pure water. To the extent you can contaminate pure water by salinity to get brackish waters our production decreases. Again inside this continuously spiraling tube there is introduced in the tube a vortex and there is a torridal motion of the liquid similar to that which might be served in the Hickman still.

Now, I have cautioned everybody that listens to me to be from Missouri. The final court of appeal is Mother Nature. You have to test it. You have to build it. You have to demonstrate it, but could I say this: If you don't get the energy consumption down you will never know what the cost of the water is because energy costs keep going up. They are very uncertain.

The one thing that you can do is to go to a banker and find out how much he wants for his money. If the cost of the initial plant is a large factor you will know the cost of the plant 20 years from now.

If you are going to invest a lot of money to save fuel don't be content with equipment that will only last 20 years. Just use central station types of equipment, that have a life history of 40 or 50 years.

Let us ask ourselves at the end of 20 years what do we have to do to make a secondhand plant like a secondhand automobile good for 20 or 30 years.

We will automatically retool the heat compressors. We will open up the compressor. We will open up the turbine. We will look at the gasifiers.

I have asked Allis-Chalmers and General Motors what does it take to rehabilitate this plant. It looks like one-third of the initial cost of this plant will take care of rehabilitation for 20 years.

However, you will read in between the lines that they have about a 5-year margin. It is not improbable that these plants can last 50 years.

Now, the most vulnerable part lifewise——

Senator CASE. Fifty years by one rehabilitation?

Mr. LARRECQ. By rehabilitation, sir, I mean exactly what is done in a central station, they may retool the condenser, parts of the boiler, they may rebraid the turbine.

They certainly will look at the cooling water pump and look at the impellers. But in this plant, sir, the thing that you will want to focus your mind on is how long are these internal-combustion gasifiers that burn fuel oil in the most direct possible manner, how long are they going to last?

That is a question that General Motors has been asking itself for a long time. I think if you will hear Mr. Brater you will see that we have here the possibility in small unitized plants of giving the same efficiency of energy conversion as you get in a 100-kilowatt steam plant.

This is a remarkably efficient means of converting the cheapest, dirtiest fuel oil into power that is on the American scene today. It is as efficient as you can generate power except in a 250,000-kilowatt steam plant.

This opens up the possibility of the city of San Diego starting out with one of these plants, adding another, adding another.

Senator CASE. What about Ardmore, Pa?

Mr. LARRECQ. They can do very well, sir. So would Newtown and Langhorne. We are all under the tyranny of 75-cent water and the process peak in a dry summer of not being able to take a bath in the evening and not even being able to flush the toilet.

Senator CASE. How far have you gone toward putting one of these plants into operation?

Mr. LARRECQ. We have been actively negotiating in Israel and we think the first plant will go up there. I am told subject to the approval of the Israel Government for dollars that will be required for engineering that they have selected this plant as being the answer over all other possibilities.

Senator CASE. Have you built a pilot plant of this character?

Mr. LARRECQ. Not of this character, but if you will look at the first page you will see the plant we have built for the Navy. It has been tested by the Navy. The thermodynamics of that plant are actually simpler than the thermodynamics of this plant we have discussed today. The telltale of engineering performance is sometimes, you might say, reduced to numbers. We took a fixed-price contract to develop that unit and the contract said that we should develop an average of 2,000 gallons per day over a 10-day period without exceeding the overload capacity of the motor.

The overload capacity of the motor is 22 amperes. We did the job with 21.8. We are usually not that smart. That was pure luck.

But if we can figure that we can figure this.

Senator CASE. The committee will recess until 1:45 and between 1:45 and 2 o'clock we will proceed with Mr. Brater and Mr. Pollack and Secretary Aandahl at 2 o'clock.

(Thereupon, at 12:50 p. m., the subcommittee was recessed, to reconvene at 1:45 p. m., same day).

AFTERNOON SESSION

Senator ANDERSON. The next witness is Mr. Eric R. Brater, assistant chief engineer of the Cleveland Diesel Engine division, General Motors Corp.

STATEMENT OF ERIC R. BRATER, ASSISTANT CHIEF ENGINEER, CLEVELAND DIESEL ENGINE DIVISION, GENERAL MOTORS CORP.

Mr. BRATER. My name is Eric R. Brater, assistant chief engineer of the Cleveland Diesel Engine division of the General Motors Corp.

After careful analysis and study Mr. Larrecq of Power Generators, Inc., came to the conclusion that the free piston gasifier turbine would be the most desirable source of power for the sea-water conversion plant which he described this morning. I would like to briefly outline the background and advantages of the General Motors development of the free piston gasifier turbine.

This engine is not new. It was developed and has been manufactured by the French during the last 30 years. There are about 131,000 horsepower units in operation in Europe at the present, and 300 units are under construction or are on order. Included in these is a 32,000 horsepower electric powerplant for Caledonia which is now being installed by the French.

This powerplant consists of 32 of these 1,000 horsepower gasifiers. Also an English firm is now installing a 48,000 horsepower electric powerplant in Singapore with 48 of these gasifiers. About 4 years ago the General Motors Corp., realizing the possibilities of this powerplant, acquired a license from the French to manufacture this engine in the United States.

The following steps were taken:

An extra unit was installed at the General Motors Research Laboratories, which has now accumulated about 10,000 hours operating on low-grade bunker C fuel.

Secondly, the Cleveland Diesel Engine division of General Motors was selected and was awarded a contract by the Maritime Adminis-

tration to install a 6,000-shaft-horsepower plant on the converted 9,000-ton Liberty ship, *William Patterson.*

This powerplant consists of 6 gasifiers and 2 turbines. The *William Patterson* has just completed the second Atlantic crossing successfully. And we are very pleased with the performance of the gasifiers. These gasifiers are burning cheaper low-grade bunker C fuel.

Furthermore, the Electric Motor division of General Motors developed a siamese or dual version of this gasifier of 2,000 horsepower, which has been developed for locomotive application or other purposes. Up to the present time about 40,000 hours of operation have been accumulated on gasifiers in the various divisions in General Motors.

The advantages of the gasifier are as follows:

Any type of liquid fuel can be burned, including cheap low-grade bunker C. Also most types of crude oil that is pumped out of the ground can be used directly.

Secondly, the gasifier construction is very simple. There is no crankshaft, no main bearing, connecting rods, connecting-rod bearings, or valve operating mechanism.

This assures continuous around-the-clock operation, which is absolutely essential for sea-water conversion plants and demineralizers. Maintenance and service problems and costs are low.

Thirdly, there is no vibration, and, therefore, an elaborate foundation is not necessary.

Fourth, the multiple arrangement of gasifiers for sea water conversion plant assures great power flexibility. As pointed out by Mr. Larrecq this morning, there are 8 gasifiers in 1 section feeding gas to 1 gas turbine. One of these can be used as a spare and can be cut in instantly, or the 8 gasifiers can be operated simultaneously at reduced load.

Also the gas turbine plant lends itself to successive continuous additions to an originally small basic plant. A basic plant of, say, 2½ million gallons per day capacity is just as economic and efficient as a plant 10 times that size.

The exhaust-gas temperature entering the turbine is at about 830°, which makes it possible to use conventional materials in the turbine, which reduces cost and maintenance. I have 3 or 4 slides which I would like to show, which indicate what this gasifier looks like.

This is a diagrammatic sketch of this gasifier. It is a highly supercharged two-cylinder diesel engine. As mentioned, there are no crankshafts, and connecting rods, and so forth.

These are two opposed power pistons, which are attached to compressor pistons.

As these pistons move outward, air is admitted through this valve into this compression chamber. In these bounce cylinders, there is a fixed quantity of air, which is compressed with an outward stroke and acts like a spring returning these pistons to the firing stroke.

During the inward stroke, the air which was compressed in this chamber is forced through these valves in the airbox, and during the outward stroke, air is admitted through air intake inlets and is simultaneously discharged through the exhaust at 830°. The compression ratio is about 30 to 1. And the instantaneous compression tempera-

ture is about 3,300°, which makes it possible to burn low-grade fuels.

The next slide, please.

This is a general view of this gasifier which makes nearly 20,000 pounds. Here are the air inlets. Here is the exhaust receiver. The unit is about 14½ feet long.

These are the bounce chamber covers.

Next slide, please.

This slide shows three of the gasifiers which were developed for the installation on the *William Patterson* undergoing tests at our plant in Cleveland. These 3 gasifiers operate 1 turbine.

The last slide here is a diagram showing the *William Patterson* installation. These are 6 gasifiers, and 2 turbines. These 2 drive 1 propeller shaft.

That concludes my statement.

(The slides and charts referred to by Mr. Larrecq and Mr. Brater are on file with the committee for reference purposes.)

Senator ANDERSON. Thank you very much, Mr. Brater.

Who is the next witness?

Mr. LINEWEAVER. Mr. Pollock.

Mr. LARRECQ. Mr. Chairman, I would just like to make one concluding remark. It will just take 1 minute.

And that is that I may wish to present a further statement for publication in the record.

Senator ANDERSON. We will be happy to receive any further views of your group and will publish them in the record at this point.

(Mr. Larrecq subsequently submitted the following letter and two enclosures. The enclosure entitled "Report 1522–A" is on file with the committee for reference.)

POWER GENERATORS, INC.,
Trenton, N. J., March 27, 1958.

From: Power Generators, Inc., 600 Stokes Avenue, Trenton, N. J.
To: Hon. Clinton Anderson, Senate Office Building, Washington, D. C
Subject: Generation of Potable Water for Municipal and Industrial Use.

DEAR SENATOR ANDERSON: We are pleased herewith a submit amplification of remarks made before your committee on March 21, 1958. Additionally, we are submitting PGI Report 1522 incorporating revisions in the light of information presented at the hearing. We shall be pleased to submit additional particulars if desired.

Respectfully,

A. J. LARRECQ, *President.*

SUPPLEMENTAL STATEMENT OF A. J. LARRECQ, PRESIDENT OF POWER GENERATORS, INC.

Power Generators, Inc., is one of three companies who in recent years has developed original and improved designs of Navy types compression distillation plants for saline water conversion. A recent prototype unit has successfully passed the exacting requirements of the United States Navy.

Mr. Chairman, numerous communities have indicated a need for supplementary potable water supply. The Federal Government cannot hope to subsidize all needy communities. Accordingly, such demonstration plants as are undertaken with Federal support should lead to economical plants which can meet immediate needs. There would be no point in subsidizing mediocrity with Federal funds.

There are basically six processes to choose from, i. e., electrodialysis, freezing, solar distillation, compression distillation, thermal distillation, and combinations of the last two. Existing commercial saline water conversion plants are either of the electrodialysis type or the distillation type. The cost of product for these

plants has been variously estimated from a low of 20 cents per thousand gallons to the present actual figure of $2.80 per 1,000 gallons for large scale multiple effect flash type distillation plants.

It generally costs less than 20 cents per thousand gallons for well water or treated natural water. Industrial users in the eastern United States are now paying as high as 30 cents per thousand gallons. Most municipalities faced with imminent water shortages are loath to pay more than 45 cents per thousand gallons, delivered at sea level. At costs above 50 cents per thousand gallons, other sources such as barge transportation, or reuse of sewage waters become increasingly competitive. Considering a cost of 10 cents per 1,000 gallons to pump water from sea level to a sufficient reservoir level to insure fire protection; a cost of product of 35 cents per thousand gallons is a realistic goal for 1960.

Brackish water is making its appearance with increasing frequency all over this country as the water table recedes. It is advantageous to develop a single system to desalinize either brackish water or sea water. However, to be economic, the system must convert saline water at a product-fuel ratio of at least 500:1, and must employ the cheapest fuel source available in the area. Most often the cheapest fuel source is residual petroleum. The cost of such fuel must be reckoned at not less than $2.50 per barrel in the next 20 years and therefore the minimum cost of potable water must be reckoned at approximately 15 cents per 1,000 gallons for fuel alone. If the product-fuel ratio is 250:1, the cost of fuel is 30 cents per 1,000 gallons of potable water. Most distillation plants built to date have a product-fuel ratio of less than 250:1. Quite obviously a new approach to saline water conversion is required for economic conversion of sea water. Such a new approach is described in Power Generators, Inc., Report 1522–A (on file with the committee).

Mr. Chairman, it is easier to talk cheap water than to produce cheap water. Any claim to lower cost desalinization is justifiably subject to critical scrutiny. It would, for example, be possible to show low costs of potable water by assuming a fictitiously low fuel cost. In this connection, caution must be exercised in accepting costs of desalinization based upon the Department of Interior's Standardized Procedure for Estimating Costs of Saline Water Conversion wherein the suggested cost of fuel corresponds to approximately $1.25 per barrel or less than half the going rate in most arid regions. Another way of showing low potable water costs is to assume cheap materials, such as never previously accepted for sea water distillation plants and for which no service record is existent. It is much more difficult to produce cheap water with the best materials and with equipments such as used in large central stations during the past 40 years for which 1-year warranty and 20-year service contracts are available.

Mr. Chairman, it is only fair to inquire by what means it is proposed to achieve the unprecedented distillate feed ratio of 500:1 for sea water and 650:1 for brackish water. Power Generators, Inc., Report 1522–A describes an old kind of heat transfer surface used in a new way to produce evaporation of sea water with an expenditure of power roughly one-third that previously achieved in the most efficient distillation plants. It is well known that heretofore the most efficient distillation plants operated at 12° F. temperature difference across the heat exchanger surface. The Power Generators' unit can operate with one-fourth this temperature difference at four times the heat transfer efficiency and thus reduce power consumption to roughly one-third without increasing the amount of heat exchanger surface. Further technical developments are in prospect and accordingly any prognostications of product cost projected in Power Generators, Inc., Report 1522–A must be viewed as conservative.

Mr. Chairman, it will be immediately recognized that if sea water can be evaporated with an effective temperature difference of 3° F. across the heat exchanger, then brackish water can be exaporated without the handicap of several degrees elevation of the boiling point, i. e., with less expenditure of power and therefore a higher product-fuel ratio. Accordingly, wherever possible, potable water should be generated from brackish water.

One of the caprices of nature is the tendency of saline waters to deposit scale on the heat exchanger surfaces above 155° F. Scale inhibitors have been successfully employed at higher temperatures but only evaporation below 155° F. in-

sures reasonable immunity from the deleterious effects of scale formation. The desalinization plant described in PGI Report 1522–A is designed for low temperature operation despite the inherent penalties of increased initial cost and somewhat less favorable power consumption as compared with higher temperature operation where scale inhibitors would be required.

A crucial consideration in the operation of desalinization plants is the manner in which the energy of the fuel is used. Many municipalities will require economic desalinization in capacities of 2,500,000 gallons per day. At 500 : 1 product fuel ratio, the power required is roughly 4,000 horsepower. Only the General Motors free-piston gasifier turbine combination will give the lowest fuel cost at this moderate power consumption in conjunction with assurance of continuous operation. This is a new development in the United States backed by 30 years' operating experience abroad with the burning of the cheapest residual fuels.

Allis Chalmers have since 1860 occupied a foremost position in steam-plant equipment. No other company in the United States produces such a wide range of powerplant equipment. Except for the free-piston gasifiers, Allis Chalmers are in a position to manufacture all the components of the desalinization plants designed by Power Generators, Inc.

It will be possible to undertake with assurance a 2,500,000 gallons per day plant for delivery in 1960 at a cost of something less than $4 million. Subsequent plants might be expected to cost roughly $3 million in this capacity. Ultimately it is believed likely that 10-million-gallons-per-day plants can be installed for less than $10 million.

In preparation for the construction of large scale saline water conversion plants all over the world, arrangements are being made by Power Generators, Inc., for the installation of calibration units in Israel, Spain, New Jersey, Wisconsin, and California. The data made available from these calibration units will permit accurate rating of heat exchangers based upon local water conditions.

It is pertinent to observe that fuel and labor costs are likely in the forthcoming years to continue upward in price. Low energy consumption plants obviously minimizes fuel consumption and thus makes for greater stability in the overall cost of product. By contrast, where the cost of product is primarily dependent upon fuel costs as in old-fashioned distillation plants, it is important to take account of the likely rise in operating costs after installation.

The proposed Senate Joint Resolution 135 aims at expending Federal funds for demonstration plants. These plants should be contracted for by local authorities based upon competitive bidding against specifications calling for a 1-year warranty and 20-year service contract. Only by such means can valid selection be made as between contending claims. It would serve no purpose to expend Federal funds on plants such as already exist in aircraft carriers and which hold no promise of economic saline water conversion. Rather, it would be more useful to demonstrate plants having the capability in sizes of 2,500,000 gallons per day of generating potable water at 35 cents per 1,000 gallons. Given such capability, local water authorities will have no trouble selling 2½-percent 40-year bonds.

With respect to the efforts of the Office of Saline Water, pilot plants of 1 million gallons per day should not be undertaken unless there is reasonable prospect of producing potable water at substantially less than 35 cents per 1,000 gallons, based upon a realistic cost of fuel, 20-year amortization, 40-year life, and 2½-percent tax-free water authority bonds. In any case, the Office of Saline Water should be encouraged to open its doors to competitive bidding for prototypes. Only by such an open door policy will the country's best talents be given equal, fair, and complete consideration. A closed door policy can only lead to stagnation.

The basic aims of Senate Joint Resolution 135 are commendable and deserving of support and passage of this resolution can be the starting point of practical solutions to an ever-increasing problem. The opportunity afforded Power Generators, Inc., to present its views is sincerely appreciated.

23642—58——11

COST ANALYSIS: 1958 Plant

Plant capacity (gallons per day)	2, 500, 000	3, 250, 000
Feed quality (parts per million)	40, 000	2, 500
Feed cost (dollars per thousand gallons)	[1] 0	[2] 0
Fuel cost (dollars per thousand gallons)	$0. 165	$0. 140
Energy consumption (kilowatts per thousand gallons)	33. 0	28. 0
Fuel rate at gas turbine (pounds per 10 horsepower hours)	. 410	. 410
Fuel consumption (pounds per thousand gallons)	18. 0	15. 5
Fuel cost at $2.50 per barrel	[3] . 47	[3] . 47
Fuel cost (dollars per thousand gallons)	. 165	. 140
Equipment cost (dollars per gallons per day), including erection	$1. 40	$1. 30
Plant cost (dollars per gallon per day), including contingency and fee	$1. 50	$1. 40
Labor cost:		
Operating personnel	8	8
Maintenance personnel	4	4
Average hourly rate (dollars per hour)	$2. 75	$2. 75
Labor costs (dollars per thousand gallons)	. 08	. 06
Operating costs (20-year amortization) (dollars per thousand gallons)	$0. 54	$0. 48
Amortization at 2½ percent interest	. 275	. 257
Fuel cost	. 165	. 140
Labor cost	. 080	. 060
Maintenance materiel (½ of 1 percent per annum)	. 020	. 020
Operating costs (20 years after amortization) (dollars per thousand gallons)	$0. 36	$0. 30
Replacements (amortized over 20 years at 2½ percent)	. 092	. 085
Fuel cost	. 165	. 140
Labor cost	. 080	. 060
Maintenance materiel	. 020	. 020
Average cost of product (dollars per thousand gallons):		
Cost of unblended distillate (dollars per thousand gallons)	$0. 448	$0. 39
Cost of 2,500 parts per million feed (dollars per thousand gallons)	. 200	. 05
Cost of 500 parts per million blended product [1]	. 400	. 32

[1] Assuming mixing with brackish water of 2,500 parts per million.
[2] Assuming desalinization of surface brackish water.
[3] Per 10,000,000 B. t. u.

COST ANALYSIS: 1960 Plant

Plant capacity (gallons per day)	10,000,000	13,000,000
Feed quality (parts per million)	40,000	2,500
Feed cost (dollars per thousand gallons)	[1] 0	[2] 0
Fuel cost (dollars per thousand gallons)	$0.165	$0.140
Energy consumption (kilowatt per thousand gallons)	33.0	28.0
Fuel rate at gas turbine (pounds per 10 horsepower hour)	.410	.410
Fuel consumption (pounds per thousand gallons)	18.0	15.5
Fuel cost at $2.50 per barrel	[3] 0.47	[3] 0.47
Fuel cost (dollars per thousand gallons)	0.165	0.140
Equipment cost (dollars per gallon per day), including erection	$1.30	[2] $1.20
Plant cost (dollars per gallon per day), including contingency and fee	$1.40	$1.30
Labor cost:		
Operating personnel	8	8
Maintenance personnel	4	4
Average hourly rate (dollars per hour)	$2.75	$2.75
Labor costs (dollars per thousand gallons)	.02	.015
Operating costs (20-year amortization dollars per thousand gallons)	$0.46	$0.415
Amortization at 2½ percent interest	.257	.240
Fuel cost	.165	.140
Labor cost	.020	.015
Maintenance material (½ percent per annum)	.020	.020
Operating costs (20 years after amortization dollars per thousand gallons)	$0.29	$0.255
Replacements (amortized over 20 years at 2½ percent)	.085	.080
Fuel cost	.165	.140
Labor cost	.020	.015
Maintenance material	.020	.020
Average cost of product (dollars per thousand gallons):		
Cost of unblended distillate (dollars per thousand gallons)	$0.375	$0.335
Cost of 2,500 parts per million feed (dollars per thousand gallons)	.200	.050
Cost of 500 parts per million blended product [1]	.340	.280

[1] Assuming mixing with brackish water of 2,500 parts per million.
[2] Assuming desalinization of surface brackish water.
[3] Per 10,000,000 B. t. u.

COST ANALYSIS: 1965 Plant

Plant capacity (gallons per day)	40, 000, 000	50, 000, 000
Feed quality (parts per million)	40, 000	2, 500
Feed cost (dollars per thousand gallons)	[1] 0	[2] 0
Fuel cost (dollars per thousand gallons)	$0. 160	$0. 136
Energy consumption (kilowatts per thousand gallons)	33. 0	28. 0
Fuel rate at gas turbine (pounds per 10 horsepower hour)	. 400	. 400
Fuel consumption (pounds per thousand gallons)	17. 5	15. 0
Fuel cost at $2.50 per barrel	[3] . 47	[3] . 47
Fuel cost (dollars per thousand gallons)	. 160	. 136
Equipment cost (dollars per gallon per day), including erection	$1. 00	$0. 90
Plant cost (dollars per gallon per day), including contingency and fee	$1. 10	$1. 00
Labor cost:		
Operating personnel	16	16
Maintenance personnel	4	4
Average hourly rate (dollars per hour)	$2. 75	$2. 75
Labor costs (dollars per thousand gallons)	0. 009	0. 0075
Operating costs (20-year amortization) (dollars per thousand gallons)	$0. 385	$0. 341
Amortization at 2½ percent interest	. 200	. 182
Fuel cost	. 160	. 136
Labor cost	. 009	. 0075
Maintenance material (½ percent per annum)	. 0155	. 0155
Operating costs (20 years after amortization) (dollars per thousand gallons)	$0. 251	$0. 22
Replacements (amortized over 20 years at 2½ percent)	. 067	. 061
Fuel cost	. 160	. 136
Labor cost	. 009	. 0075
Maintenance materiel	. 015	. 015
Average cost of product (dollars per thousand gallons):		
Cost of unblended distillates (dollars per thousand gallons)	$0. 318	$0. 280
Cost of 2,500 parts per million feed (dollars per thousand gallons)	. 200	. 005
Cost of 500 parts per million blended product [1]	. 295	. 230

[1] Assuming mixing with brackish water of 2,500 parts per million.
[2] Assuming desalinization of surface brackish water.
[3] Per 10,000,000 B. t. u.

SUMMARY

By virtue of the successful demonstration of a unique heat transfer surface, as also by virtue of the employment of the latest type prime mover within an optimum thermodynamic framework; it is now, for the first time, possible to envisage economic desalinization of sea water and economic reclamation of potable waters from industrial and municipal effluents.

Senator ANDERSON. Our next witness will be Mr. W. R. Hainsworth, of the Fluor Corp., of Los Angeles.

Your complete statement will be placed in the record.

STATEMENT OF WILLIAM R. HAINSWORTH, VICE PRESIDENT OF THE RESEARCH DIVISION, THE FLUOR CORP., LTD., LOS ANGELES, CALIF.

Mr. HAINSWORTH. My name is William R. Hainsworth, and I am vice president of the Fluor Corp., of Los Angeles, California. By way of introduction, I would like to say that the Fluor Corp. is an engineering and construction company in the business of building refineries and powerplants and nuclear plants. And we are affiliated with Singmaster & Brier, an engineering concern in New York, who have engineered and constructed the Aruba plant for the distillation of salt water. In my work as head of research we have been doing some studies for the Office of Saline Water, and one of these studies involves the use of nuclear energy combined with the distillation process.

And I would like to say just a few words from the point of view of the technology of the nuclear plant, and that is that such plants must necessarily be very large. They are not adaptable to energy sources as a supply for energy for small-size plants. And that necessarily ties us in with the production of fresh water from salt water on a very large scale. This fits in with the requirements of certain areas; for example, the southern California area where we all know that the water consumption is very high, and there are some critical situations. We have already heard some statements to the effect that the growth factor there is such that a plant in the neighborhood of a hundred million gallons a day would be required every 2 or 3 years in order to take care of the incoming population of all the water was supplied through that medium.

Of course, it will not all be supplied through the medium of plants, but, even to be of interest as a supplemental water supply, the plant would have to be very large. So, we are talking about plants on the order of magnitude of ten to a hundred million gallons of water a day.

Senator ANDERSON. Are you going to mention what systems you were using with the proposed nuclear reactor?

Mr. HAINSWORTH. Yes. I was coming to that. The work for the Office of Saline Water, which, incidentally, is not of the type which we have talked about before in the meeting here, but this research and work for the Office of Saline Water was more of a design study of a large plant. It was removed from the research end of the situation. And I think we were the first to get into that type of a study involving the use of a nuclear plant in combination with distilled water.

We, as a result of that study, selected a reactor which is charged with natural uranium and moderated and cooled with heavy water. We had a choice of reactors, of course. But we were—the objective was to supply heat at the lowest cost from a reactor system. This is what we came up with after going through quite a few different types of reactors.

Senator ANDERSON. Did you have any degree of enrichment at all?

Mr. HAINSWORTH. No. In this case, we are not talking about enrichment. I might say that there is some experience in the background, although all of the information is not readily available to us, in that a natural-uranium and heavy-water reactor has been built

in Canada. The Chalk River was a smaller experimental unit. But the larger plant is just being completed up there of 200 megawatts of this type, but for power production, not for just heat production. And power and plutonium production.

Now, I have a few slides here. I think, if we can look at these, I will be able to explain them a little better.

(The slides referred to appear in Mr. Hainsworth's prepared statement following his oral testimony.)

In describing this system, I am going to review very briefly the results of the study which was made for the Office of Saline Water and then relate that to the demonstration plant we are talking about in connection with the proposed bill. This is, of course, a very schematic diagram, but it shows just the manner in which the reactor is hooked up to the distillation system (slide 1).

We have a reactor in this position, and pressurized heavy water within the circuit, and the steam forming in the separate vessel. Then that steam is being used in the multiple-effect distillation plant. Sea water coming in and fresh water going out.

Now, this part here we can imagine—well, let's compare for a minute this type of a system with a powerplant system where we have a reactor supplying steam for the powerplant and a turbine setup over here. Now, if we were talking in this kind of a proposal here about the same economic relationships that we have when using steam for power purposes, we would really have nothing much to talk about, because we all know that the cost of power from a nuclear plant at the present time is not competitive with power coming from conventional fuel plants.

The big difference in this system which gives us some encouragement to follow through with it, and is quite economical as far as fuel cost is concerned, is the fact that the requirement for distillation is very low temperature steam in comparison with the requirement for power production. If we have steam available here in the neighborhood of 200° or a little more, it is perfectly satisfactory for this purpose. Whereas steam has to be up to 1,000° or a fairly high pressure to be of any real value in the power-production plant.

Under those conditions, the reactor can be designed on an entirely different basis. We do not have to have as heavy pressure vessel. We do not require the use of materials such as zirconium. We can go over to aluminum. And there are a number of factors throughout the whole system which greatly reduce the cost of steam from that low-pressure type of unit.

Now, may I have slide 2 projected?

Without going into detail of all the factors which contribute to the lowering of this cost of steam, I have selected just the two types of cladding for the fuel elements. Using aluminum cladding and compared with zirconium cladding we see that the fuel cost—represented by this side of the chart—is much lower; in fact, almost half the cost of the zirconium cladding.

The bottom terminology here where we say maximum exposure level, megawatt-days per metric ton, this is simply a measure of the amount of energy extracted from the uranium. And it also determines how long the uranium stays in the reactor. If we can extract more energy, of course, a batch of uranium can stay in the reactor for a longer

period of time. And that, in turn, materially reduces the cost, because there is less reprocessing and less work involved in recovering the plutonium.

So, you see, there is another factor here shown. And that is the enrichment percent. This 0.71, of course, is natural uranium and is in the area that we are talking about. So you can see that the aluminum cladding, as compared with the zirconium cladding in that case, accounts for a very large difference in the cost of fuel itself. This is for a 13-foot diameter reactor core.

This shows the effect of reactor power level or reactor sides on this cost of fuel, cost of steam. We speak of it in terms of cost of steam. We have here (slide 3) steam cost in cents per million B. t. u.'s. At the bottom of the chart we have 2 scales, 1 is megawatts and the other is identified as millions of gallons per day.

This is megawatts, of course, in terms of thermal energy or heat energy and not in electrical energy. It is just a measure of the amount of heat energy that we are drawing from this reactor. If we were using it as a powerplant, thermal energy may be up here around 300, and that is because of the efficiency of the power system. So this 300 here would correspond to a hundred megawatt electrical powerplant on the order of magnitude. You can see that something under 200-megawatt plant would be needed for a million gallons of water per day.

Now, the curve drops fairly sharply. And you can see that the cost of heat from a reactor down to relatively small sizes is up in the same order of magnitude as the same cost of heat which was selected by the Office of Saline Water as the standard figure for comparative purposes. Here we have 55 cents per million B. t. u.'s, or practically the same as 55 cents per thousand pounds of water. At this level, then, there is no particular advantage in using reactors. We have to go to larger sizes. Another type is involved in that this reactor of the natural uranium, heavy-water type, has to be of a certain size before it will be critical; and we cannot make a unit which would use natural uranium and be at all practicable in this lower end of the chart.

These two points here are based on published information and studies made by others which indicated that at this low level heat from the reactors is about comparable with the heat from the conventional fuel.

But here, again, you can see that we have reduced the steam cost down from 55 cents, the standard value, down to about 20 cents, when we get out into the larger sizes.

Seantor ANDERSON. What size is that?

Mr. HAINSWORTH. This is 10 million gallons per day here.

Seantor ANDERSON. When you are down to the 20 cents, what size is it?

Mr. HAINSWORTH. Twenty cents is way out here at 50 million gallons per day where it levels out. The type of reactor in this area is different from this. And that is the dotted line. So that there is really no connection. This is a light water moderated plant and slightly enriched in uranium. So we are talking about two different types.

The point I wanted to make, though, is that the cost from the reactor of the large size, the cost of the steam, is less than half of the steam from conventional fuel plants. And we go up to the standard figure used by the Office of Saline Water.

Now we go to slide 4.

Here we have the water cost against the plant capacity for seven-effect combination evaporator. Plant capacity in millions of gallons per day. The chart ranges from 10 million to 60 million gallons per day. The water cost is in cents per thousand gallons. Let me say the seven-effect combination evaporator, we are talking about the combination of the flash and the multiple-effect evaporator. Both of these have been described by previous witnesses. And our main purpose in making this study was to try to pick out what we thought to be the best distillation plant to be combined with the reactor plant to produce lowest cost water. It turned out that the seven-effect combination evaporator, combined with the multiple-effect evaporator, gave us the lowest cost.

Senator CASE. In your discussion of this in your paper I notice you said this was based upon using aluminum brass tubes in the distillation plant, or if later on it is found possible, by using inhibitors or other means, to use steel tubes, it is estimated that the cost would be reduced to less than 50 percent per thousand gallons for the large-scale plant.

Do you think it is practical to use steel tubes?

Mr. HAINSWORTH. That is part of the program which is being investigated by the Office of Saline Water. And we also made use of what they called the long-tube vertical-type evaporator which Mr. Badger described. And depending on the results of the research and the efforts which are being made now, it may be that parts of this plant or maybe the whole plant could go over to carbon steel type of tubing. This cost here is based on the alumnum brass which is intermediate in cost between the nickel and carbon steel.

Senator CASE. Would the carbon steel be usable if we are dealing with briny water?

Mr. HAINSWORTH. That is what we are attempting to find out. We are attempting to find out how long the carbon steel will last and what the effect would be through these experiments which are now underway. That is why these cost figures are based upon the use of aluminum brass or an alloy which we know will last a great deal longer than carbon steel. That comment was thrown in simply to indicate the magnitude of the saving which might result if we were able to go to carbon steel and not use the more expensive element. That would bring it down to less than 50 cents. This curve would move way down.

I show 2 curves on here, 1 market, 4-percent industrial financing, and 1 market, 2½-percent Government financing. This again shows the effect of the cost of money on a plant of this type. This 20-year amortization, 4-percent money, would be reasonable for an industrial plant if the plant were made available by the Government for 2½-percent money just for purpose of illustration with no taxes and insurance; the reduction in cost of water for the large-size plant would be in the neighborhood of 15 cents.

In order to get some idea of the total amount of money involved in a plant of this type, and again I am talking about a large plant capable of producing, say, 10 million to 50 million gallons of water a day, I submit the following table so as to show the capital cost and then the estimated water cost. The reactor itself, you see, is less in amount of money involved in the reactor than the distillation plant. Ten million gallons per day of $5,500,000, and a distillation of $9,123,000. If we

use the industrial financing, it is 4-percent interest, with a 20-year life, which would come out to a cost of 77 cents. And going to the 50-million gallons per day plant, we would come out to 63 cents. The cost using Government financing would be somewhat less.

Plant and water costs

	Plant capacity	
	10,000,000 gallons per day	50,000,000 gallons per day
Plant cost:		
Reactor	$5,500,000	$17,100,000
Distillation	9,123,000	45,615,000
Total	14,623,000	62,715,000
Water costs (cents per 1,000 gallons):		
Conventional industrial financing	77.3	63.0
Assumed Government financing	64.8	53.9

I skipped through this hurriedly without getting into too much detail of the study. But the study was based upon quite a bit of detail.

This is not based on the definitive estimate for a plant of this size to make a real engineering or definitive estimate of cost. Even a design-study estimate would cost in the neighborhood of $130,000, and if you got into an engineering estimate, to do all the engineering work involved to permit you to build the plant and get it real close might run up as high as a half-million dollars, just to do the engineering work, that is. So the accuracy of these figures has to be related to the amount of time and effort that we put into it, of course, which was relatively small in comparison with those detailed studies.

Senator ANDERSON. Why did you go to natural uranium in heavier water?

Mr. HAINSWORTH. We went to that type after analyzing the several other types which might be suitable for this purpose, for use with aluminum of the size we were interested in. And it just came out as a basis of this study that the cost from this type of reactor was less than the light water partially enriched type. Now, there are some uncertainties, of course, which have to be worked out in a period of time. We made certain estimates on the loss of heavy water in this plant based on the experience, published experience, by the AEC and others. And we had to use certain other factors in going from one type of plant to another. So we can't say that this is an absolute figure. But it certainly is not too far out of line, in our opinion.

I am relating this to a demonstration plant. I think that such a thing would be feasible in spite of the fact that they are talking about a total cost here of $14 million. It would be possible to make use of a full-scale reactor which would perhaps—well, which we know would be capable of supplying more energy than is needed for, say, a million or 2 million gallons-a-day plant. But use that reactor in combination to a much smaller distillation plant and bring the combined cost well within the $10 million that is proposed for this type of a demonstration plant. That plant, if placed in an area where there is some assurance that additional water will be needed as time goes on could then

be enlarged by simply adding distillation units to provide for that in the original design and bring the plant on up to the 10 million gallons.

The reason we propose that type of a procedure is to enable the collecting of engineering and test data on a type of reactor which we propose to use for the largest size. If we used a smaller reactor, which could be used, of a different type, then we would not have the information to permit us to scale up to another type of reactor. And for that reason we propose that the demonstration plant, if selected to be combined with the nuclear plant, be powered by a reactor of this type capable of producing more power than is needed by a much smaller distillation plant.

There are several other points I would like to make. One is that in the California, southern California area, for example, if we are talking about a hundred million gallons a day plant, the amount of energy required to operate that plant of a distillation type becomes an important factor in relation to the amount of fuel—gas, for example—that is brought into that area. A hundred million gallons per day plant would take almost 10 percent of the amount of natural gas which is brought into southern California at this time, which means that a nuclear reactor subject to that type of a limitation or consideration would in the long run prove to be much more satisfactory.

There is another point which as an engineer I do not know whether I should make much of a point of; but there is a factor of prestige, of being the first to build a nuclear plant for the purpose of distillation of salt water, for whatever that may be worth in relation with other countries.

Also, obviously this plant could be installed in other places where a large volume of water was required.

I think that about covers what I have to say in the way of decription.

Senator ANDERSON. Well, we thank you very much.

Mr. HAINSWORTH. Thank you.

(The prepared statement of Mr. Hainsworth is as follows:)

PREPARED STATEMENT OF WILLIAM R. HAINSWORTH, VICE PRESIDENT OF THE RESEARCH DIVISION, THE FLUOR CORP., LTD., LOS ANGELES, CALIF.

Mr. Chairman and gentlemen of the committee, I appreciate very much your invitation to appear here today. My name is William R. Hainsworth and I am vice president of the research division of the Fluor Corp., Ltd., located in Los Angeles, Calif.

Our interest in the production of potable water from saline water extends over a period of several years. We have been motivated by both concern of what impact a water shortage would have on the economic development of our country and the realization that sea-water conversion plants, of whatever type they may be, would necessarily involve tremendous engineering effort, which is the principal business of the Fluor Corp.

It is recognized that the water-shortage problem must be studied from many points of view. The small isolated community is subject to an entirely different set of economic and supply considerations than is a major populated area. The optimum process and equipment used may be entirely different for the two cases. The Office of Saline Water program properly includes research and studies of many systems showing promise for these various applications. Our interest is centered in large-scale conversion plants.

As a result of our initial investigations, we realized that an enormous quantity of water would have to be desalted if converted saline water is to materially augment our natural water supply for a major area, such as southern California. This, combined with Fluor's familiarity with the design and engineering of large nuclear reactors capable of supplying the energy needed for large-scale conversion plants, led to a contract with the Office of Saline Water. The contract

covered a study of the applicability of combining nuclear energy with saline water distillation processes. Much of the information presented here resulted from that study, which has been completed.

Since the study was largely concentrated on the economics of the reactor and distillation system, it is important to stress the need for standardization of cost methods in order to compare various conversion processes using a common denominator. The Office of Saline Water has contributed materially to this standardization and procedures for sound economic evaluation. On the other hand, using these figures for comparisons with the cost of natural water where true costs either are not known or are not reflected in water rates often leads to erroneous conclusions.

The projected annual rate of population increase in the southern coastal area of California is about 220,000 people a year for the next 10 years. Assuming a per capita consumption of 150 gallons a day (present consumption is about 170 gallons a day), the yearly increase in water needed corresponds to an increase in capacity of 33 million gallons daily. A 100-million-gallon-a-day saline-water conversion plant would have to be built every 3 years to meet this requirement. This quantity of water must be added to the present consumption rate of about 900 million gallons a day. However, a plant to produce supplemental water of only 10 million gallons a day capacity would be large in comparison with the 2.7-million-gallon-a-day plant now being completed on the island of Aruba by Singmaster & Breyer, an affiliate of the Fluor Corp. This will be the largest single plant in existence when completed in 1958.

These figures are cited only to illustrate the magnitude of water requirements in the southern California area. Furthermore, the energy required for a 100-million-gallon-a-day plant would amount to approximately 10 percent of the natural gas now being supplied to the area. The equivalent large quantities of energy from nuclear sources could be supplied without materially affecting the supply-demand balance for fossil fuels.

Nuclear powerplants are not at present competitive with fossil-fuel powerplants. On the other hand, the steam temperature requirements for a distillation plant are considerably less than the temperature requirement for a steam-electric powerplant. Our study indicated that many of the cost factors associated with nuclear powerplants were related to the temperature of the system and, therefore, the costs might be considerably reduced in a low temperature reactor.

We have concluded that the cheapest low-temperature steam in large quantities is produced by a natural uranium-fueled, heavy water-moderated reactor. Steam produced from the reactor is used in a multiple-effect distillation plant to convert the sea water. The reactor dimensions must be quite large in order for the system to sustain a neutron chain reaction. A minimum-size reactor of this type is capable of generating enough steam to distill at least 10 million gallons of water a day.

Following is a brief discussion of some of the features of this reactor. The use of low temperatures in the reactor compared with the comparatively high-temperature reactors used for power production permits the use of aluminum-clad fuel elements in place of more costly cladding, such as zirconium. This feature has far-reaching effects and results in reducing the fuel component of the steam cost over one-half.

The steam cost from the reactor decreases with the increasing size of the reactor. For large reactors capable of distilling 50 million gallons a day, the cost of steam is less than one-half the Office of Saline Water's cost of 55 cents per million B. t. u. based on fossil fuels. This is comparable to and, in many cases, less than the cost of using exhaust steam from a large powerplant as determined by a detailed study of the cost of exhaust steam made by the Fluor powerplant department. The advantage of using the reactor is elimination of the need for relating water production to power requirements for a particular area.

The water cost, using a nuclear reactor with a 7-effect evaporator, remains constant for plants above 40 million gallons a day and amounts to about 63 cents per thousand gallons. This figure is based on Office of Saline Water procedure where applicable, using 4 percent interest and normal industrial plant charges. On the other hand, if, for example, it is assumed that Government financing may be obtained at 2½ percent, combined with elimination of taxes and insurance, the cost of water would be reduced to 53 cents per thousand gallons. For smaller plants, the cost rises rapidly and at 10 million gallons a day, the costs are 77 cents and 63 cents, respectively. All of these figures are based on the use of aluminum brass tubes in the distillation plant. If later on it is found possible,

by using inhibitors or other means, to use steel tubes, it is estimated that the cost would be reduced to less than 50 cents per thousand gallons for the large-scale plant.

The capital and water costs for a 10- and 50-million-gallon-a-day plant are shown in the following table:

Plant and water costs

	Plant capacity	
	10 million gallons per day	50 million gallons per day
Plant cost:		
Reactor	$5,500,000	$17,100,000
Distillation	9,123,000	45,615,000
Total	14,623,000	62,715,000
Water costs:		
Cents per 1,000 gallons conventional industrial financing	77.3	63.0
Assumed Government financing	64.8	53.9

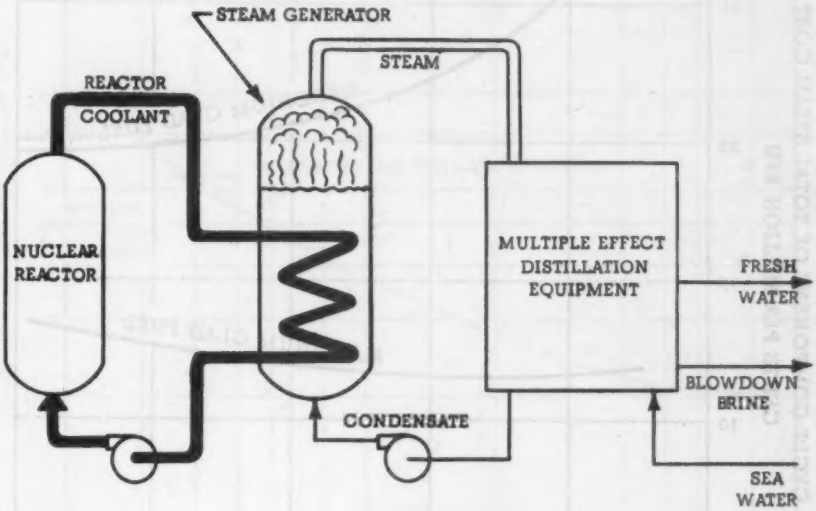
The above discussion is a bare outline of the work done on the reactor-distillation plant. Details are contained in reports submitted to the Office of Saline Water. As a result of this work, we believe that the combination is capable of converting sea water to fresh water in quantities larger than 10 million gallons a day at less cost than any other currently practicable process known to us. Also, it is believed that the technology necessary to permit the design and construction of a demonstration plant has been established.

Since the natural uranium, heavy-water reactor must be above a certain size (equivalent to approximately 10 million gallons a day) to support a chain reaction, a demonstration plant would involve the use of a much larger reactor heat supply than is needed for a distillation plant of 1 or 2 million gallons a day. Smaller reactors using enriched uranium and light water, for example, could be made to match the smaller water quantities but the cost of steam would be higher and such a plant would not provide a direct demonstration of the cost or the required engineering data for water from a plant capable of providing 10 million gallons or more a day.

One possibility would be to build the large reactor in combination with a relatively small distillation plant and operate the reactor at a low level. Provision for the future utilization of the excess reactor steam can be incorporated in the plant design. This would provide factual operating data and enable conversion of the demonstration plant to an efficient 10-million-gallon-a-day plant later on by adding distillation equipment. Such a plant may be suitable for use in the San Diego area or in an area where there is potential use for at least 10 million gallons of water a day. It is believed that such a demonstration plant, including engineering, can be built within the proposed $10-million appropriation. An engineering study would be required to definitely establish that this can be done. Also, it should be noted that the United States Atomic Energy Commission is interested in the possibilities of producing lower level heat energy from reactors. Another factor which is outside the jurisdiction of the engineer but which should be considered in connection with the use of nuclear heat to produce fresh water is the prestige for the United States to be the first to demonstrate the practicability of such a system.

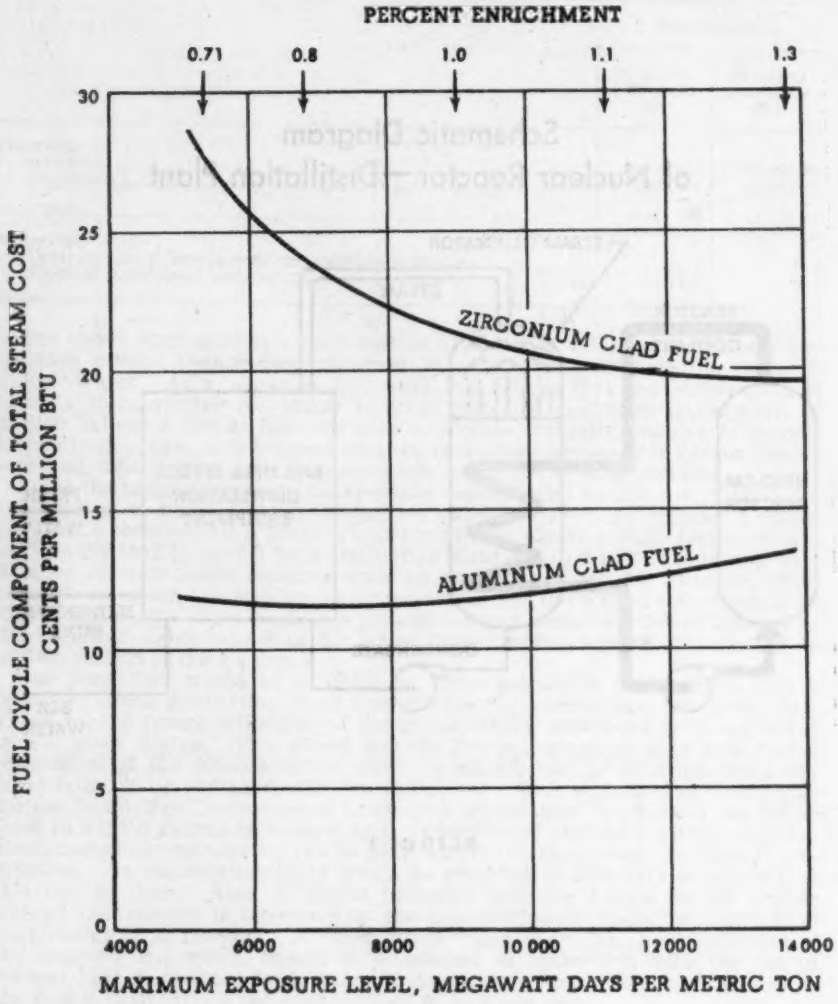
It is our opinion that the Senate Joint Resolution 135 is timely and we respectfully urge favorable action by the committee.

Schematic Diagram of Nuclear Reactor—Distillation Plant

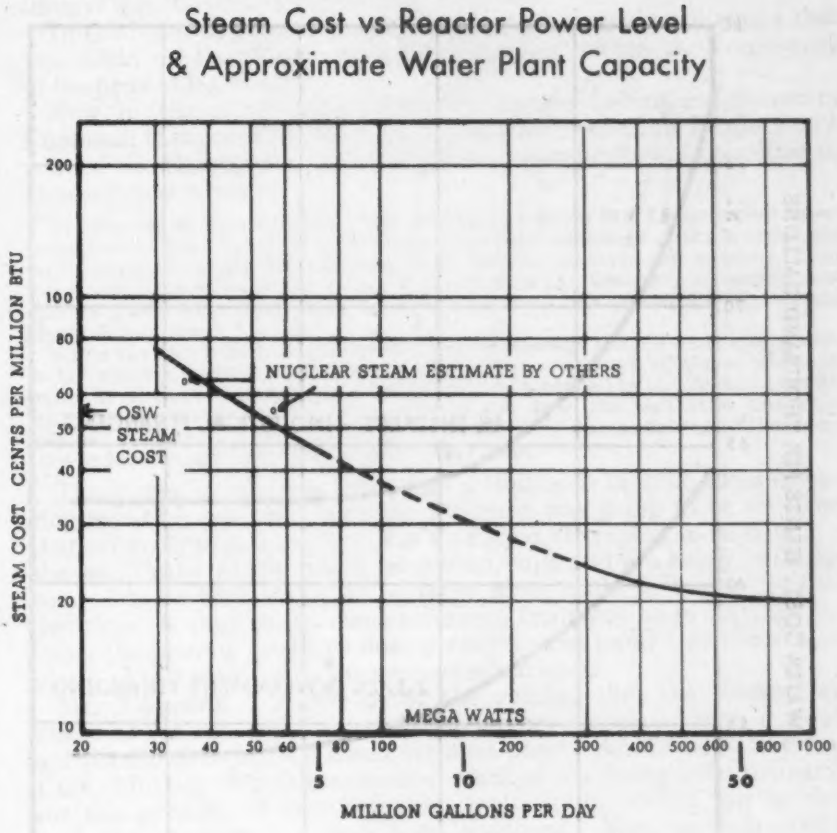


SLIDE 1

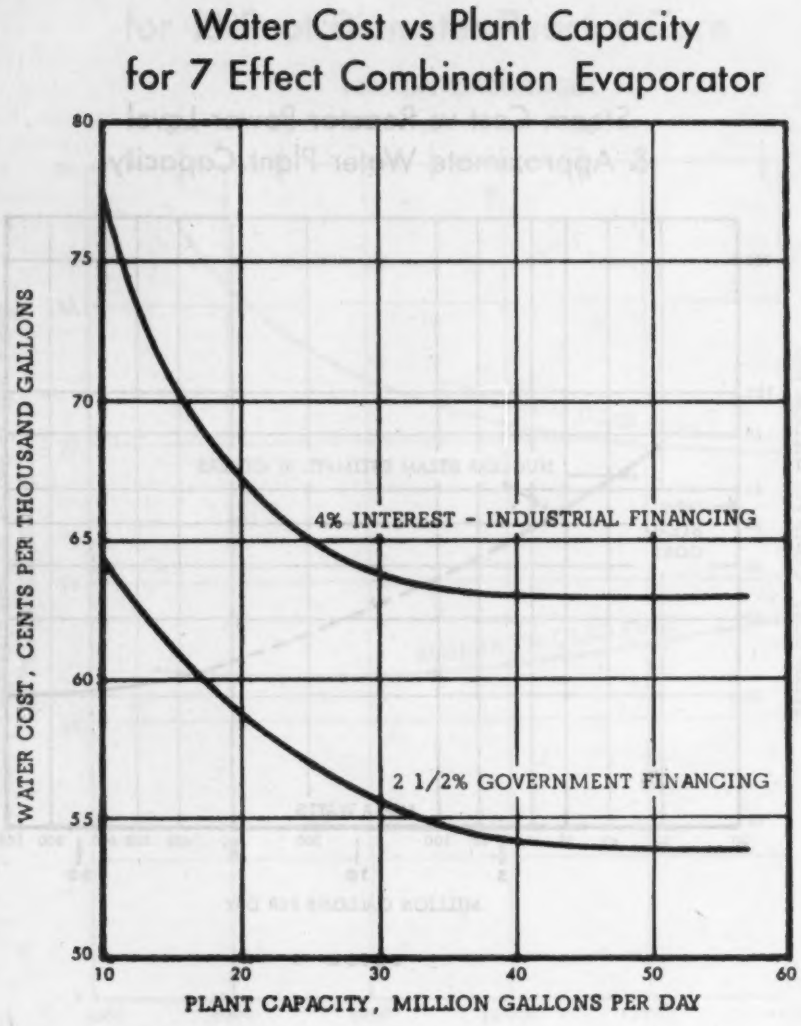
Steam Cost for 13-Foot Diameter Reactor Core



SLIDE 2


Steam Cost vs Reactor Power Level
& Approximate Water Plant Capacity
STEAM COST CENTS PER MILLION BTU
200
100
80
60
50
40
30
20
10
NUCLEAR STEAM ESTIMATE BY OTHERS
OSW
STEAM
COST
MEGA WATTS
20 30 40 50 60 80 100 200 300 400 500 600 800 1000
5 10 50
MILLION GALLONS PER DAY

SLIDE 3


Water Cost vs Plant Capacity
for 7 Effect Combination Evaporator
WATER COST, CENTS PER THOUSAND GALLONS
80
75
70
65
60
55
50
4% INTEREST - INDUSTRIAL FINANCING
2 1/2% GOVERNMENT FINANCING
10
20
30
40
50
60
PLANT CAPACITY, MILLION GALLONS PER DAY

SLIDE 4

STATEMENT OF FRED G. AANDAHL, ASSISTANT SECRETARY OF THE INTERIOR, ACCOMPANIED BY DAVID S. JENKINS, DIRECTOR, AND JOSEPH J. STROBEL, CHEMICAL ENGINEER, OFFICE OF SALINE WATER—Resumed

Senator ANDERSON. Mr. Aandahl, we are prepared for you at this time, if it is convenient for you and your staff.

In the letter in your testimony, I believe there is the statement that you could do the things we were discussing within the framework of the present legislation.

Now, in this matter—this matter was up once before, and Secretary Chapman then, on June 30, 1952, wrote a letter to Clair Engle, chairman of the Reclamation and Irrigation Subcommittee, Committee on Interior, and it reads:

> In response to your request, I am writing to confirm Mr. Lineweaver's representations to you that it is the firm position of the Secretary of the Interior and the Department of the Interior that H. R. 6578 in the form now pending before the House of Representatives does not authorize the Secretary to acquire and operate a demonstration plant in connection with the conversion of salt and brackish into use * * *
>
> While the Department recommended such authority, the bill as it now stands, in my opinion, clearly rejects that authorization. In view of the explicit language in H. R. 6578 as passed by the House and amended in the Senate, together with the discussions in committee and on the floor, the legislative history of this bill is clear that the Congress intended to deny any authority to the Secretary to acquire and operate a demonstration plant.

There was, as you may have had a chance to be told, some discussion in which one branch of the Congress was going to be very sure that no demonstration plant was built, and attempted to restrict it to the small pilot plants which have been built and are being built, but wanted to be very sure that no large plant could be built. So that, therefore, I want to get some comment from you as to whether you think the present language does permit you to build a demonstration plant. I had better go to the memorandum here.

Mr. AANDAHL. I would be of the opinion that the present language of the bill and the legislative history associated with it would not permit us to build a demonstration plant. And, when I say that, I am thinking of a demonstration plant as one being built primarily for the purpose of demonstrating to the public what can be done with the processes that have been developed. Now, as contrasted to that, I think of a pilot plant of any size. And a pilot plant is one that is built for the purpose of exploring additional means of improving and making more efficient the system of converting.

Senator ANDERSON. We had, yesterday, 2 or 3 presentations that indicated companies might be ready, willing, and able to build plants to handle up to a million gallons a day.

And one estimate was given after preparation of site that such a plant might cost in the neighborhood of $1,600,000. Another one, as I recall it, was something like $1,250,000. In the neighborhood of $1 million to $2 million for a plant to handle a million gallons a day.

Would it be your opinion that a plant of that size, costing in the neighborhood of $1½ million to $2 million, would be a pilot plant or a demonstration plant?

Mr. AANDAHL. That would depend entirely on the purpose of its construction. If it were recognized, in the analysis of the process that is proposed, that it is still short of its ultimate goal in efficiency and the plant were being built for the purpose of exploring ways and means of improving it, I would consider it as a pilot plant and one that was authorized under our present legislation.

But, if all of the information that we had indicated that the process and the design of the plant was one that was thought to be perfected almost to the maximum that could be expected of it, it would then fall in the category of a demonstration plant. And I don't think we would be authorized to build it.

Senator ANDERSON. Solely to be sure we get the legislative history, may I put this memorandum in the record:

INTERIOR DEPARTMENT MEMORANDUM FOR SENATOR ANDERSON

In Assistant Secretary Aandahl's letter of March 19, reporting on Senate Joint Resolution 135, it was stated that "It is our opinion that the Department may continue to proceed * * * with the phase of pilot-plant development under existing authority without the enactment of further legislation such as Senate Joint Resolution 135 or S. 3370."

From the testimony of Dr. Badger and others, it would appear that the progress toward solution of sea-water conversion and treatment of brackish water had proceeded beyond the so-called pilot-plant stage.

Therefore, for the Secretary of the Interior to proceed with the demonstration plant, further legislation seems necessary, together with the appropriation of additional funds specifically for this purpose.

The legislative history of the Saline Water Act of July 3, 1952, as amended in 1955, clearly indicates that it was the then intent of Congress not to authorize demonstration plants. While the act of 1952 indicated that pilot-plant operations might be undertaken, the legislative record, as shown by letter of June 30, 1952, from former Secretary Chapman, committed the Department of the Interior to recognition of the lack of authority to acquire and operate "a demonstration plant."

In the testimony yesterday it was emphasized that demonstration plants are now in order, both for the desalting of sea water on a larger scale than the so-called pilot plant operation, as well as in the treatment of brackish water on a scale not possible of being undertaken under a pilot-plant program.

The situation in the Virgin Islands requires attention in view of the urgency of providing an additional supply of potable water, as well as additional power on the island of St. Thomas. It is understood that legislation authorizing the Virgin Islands Corporation to issue bonds for the installation of a combination electric power and sea-water desalting plant is in preparation. Under these circumstances, it certainly would be well for the Department to consider a demonstration of improved methods of desalting sea water in the way of a utilitarian operation while the desalting process is being perfected.

For some reason, the Department has been opposed to using the Virgin Islands operation for demonstration purposes in connection with the saline-water program, although both the Virgin Islands and the saline-water program are under the jurisdiction of the Secretary of the Interior.

In Secretary Chapman's letter of June 30, 1952, to Representative Engle of the House Interior Committee, he stated:

It is our opinion that the Department may continue to proceed with the phase of pilot-plant development under existing authority without the enactment of further legislation such as Senate Joint Resolution 135 or S. 3370. From the testimony of Dr. Badgers and others, it would appear that the progress toward solution of sea-water conversion and treatment of brackish water has proceeded beyond the so-called pilot-plant stage.

Therefore, for the Secretary of Interior to proceed with the demonstration plant further legislation seems necessary together with the appropriation of additional funds specifically for this purpose. The legislative history of the Saline Water Act of July 3, 1952, as amended in 1955 clearly indicates that it

was the then intent of Congress not to authorize demonstration plants. While the act of 1952 indicated that pilot-plant operations might be undertaken, the legislative record as shown by the letter of June 30, 1952, from former Secretary Chapman committed the Department of Interior to recognition of the lack of authority to acquire and operate a demonstration plant.

Mr. AANDAHL. What letter is that, Senator?

Senator ANDERSON. Right here. The letter of Secretary Chapman which I just read.

The point is that when it is in the legislative history at the time a piece of legislation is being considered, we have to be really careful that you aren't caught by it at a subsequent time.

From the testimony yesterday it was emphasized that demonstration plants are now in order for the desalting of sea water on a larger scale and the so-called pilot-plant operation as well as in the treatment of brackish water on a scale not possibly being undertaken in the pilot-plant program.

The situation in the Virgin Islands requires attention in view of the urge of supplying a larger supply of potable water.

It is understood that the legislation authorizing the Virgin Island Corporation to issue bonds for installation of a combination electric power and sea-water desalting plant is in preparation.

Under these circumstances, it certainly would be well for the Department to consider a demonstration of improved methods of desalting sea water. For some reason the Department has been opposed to using the Virgin Islands operations for demonstration purposes in connection with the saline-water programs. Although the Virgin Islands and the saline-water program are under the jurisdiction of the Secretary of Interior.

What I am trying to get to is this: I realize you have said very frankly that if it was in the process of still developing you would regard it as a pilot-plant operation.

Now, Senator Case is interested in the situation in the northern Great Plains. There was testimony from Ionics, as I remember it, that it now has sufficient knowledge it believes so that it could build a million-gallon plant. And it is prepared to do so.

It wouldn't take any time to get ready for it at all. Such a plant would, of course, very nicely meet the present problem that Senator Case has in mind, because it would pretty well establish whether a future refinement would make this a usable process, on the membrane process, for the improvement of brackish water.

Do you believe that under your present authority, you could build a million-gallon ionic membrane process plant in the northern Great Plains area? Or do you need specific legislation such as Senator Case has introduced?

Mr. AANDAHL. I think a million-gallon plant of the ionics type would be much beyond the scope of what we could cover with a pilot plant.

Senator ANDERSON. That is exactly why we wanted to be sure that the testimony couldn't be construed as promising that it could be done and then we would find out subsequently it couldn't be done. I am not trying to—I know you don't think that I am trying to accuse you of bad faith. Because that is the last thing I want to say. I want to say that very frankly.

Mr. AANDAHL. I didn't feel the slightest implication.

Senator ANDERSON. You, in good faith, sent us a letter. We want to be sure that if a 1-million-gallon plant is desirable in the northern Great Plains area and if, in addition, that two or three 1-million-gallon plants might be put into the remainder of the country, such as, for example, a location close to 1 of the great centers of population on the west coast, maybe another 1 close to a substantial center of population on the east coast, do you believe that those 2 plants in which processes that have been developed in pilot plants might be to some degree expanded but would be far below the level of final operation?

Would demonstration plants be permitted under the law as it now stands or do they need some such enabling legislation as I have proposed in 135?

Mr. AANDAHL. The reason I answered as I did in the case of the Ionics plant is because it is my understanding that a single unit that would be used in the Ionics process is pretty much self-sufficient. And that single unit would not anywhere near approach the production of water that you suggested.

Therefore, a plant of that size will be a series of a good many units. And when you start doing that, you are going beyond the piloting and experimenting stage and you are getting into what I would feel would be very definitely a demonstration plant.

Senator ANDERSON. Now, Dr. Badger——

Mr. AANDAHL. Now when we come to the other process which I, for simplicity in terms, call the Badger long-tube converter, that is a process for pilot exploration.

It requires a plant of a million or more gallons per day. So we could get up into that size very nicely. If you were going up to a plant of 20-million-gallon capacity, we would have, at least, to look at it a second time before we could characterize it as a pilot plant.

Senator ANDERSON. Yes, sir. I think I would say that when it got up to 20 million gallons, it would be on the pilot-plant stage.

Mr. AANDAHL. Yes, sir.

Senator ANDERSON. What I am very anxious to have is assurance that the plan proposed by Dr. Badger, the plan proposed by Maxim Silencer, the plan proposed by Griscom-Russell, and all others similarly situated—I am not trying to tell the Secretary of Interior which ones he will build—I am only trying to use words and things which I listened to yesterday with a great deal of interest. But do you believe that those plants which I have outlined would require additional legislation for their organization in view of the legislative history behind the present bill?

Mr. AANDAHL. I have specifically reflected on the possibilities of the Badger plant, the W. L. Badger type of plant.

And like I said before, I am confident that under the authorization of the present act we could build a plant of that size. I am inclined to think that somewhat the same analysis would apply to the other two that you mentioned. But I haven't checked those as much in detail.

Senator ANDERSON. I think that is a good and fair answer. Now, Mr. Secretary, one of our problems is that when it gets to the Appropriations Committee of the Senate and House, the Appropriations Committee has held down Mr. Jenkins because of the provision in the law, or the understanding in the law that we will build only pilot plants instead of demonstration plants.

You see what we might run into. Where you would be willing perhaps that the Appropriations Committee would say this thing is barred under the Appropriations Act.

It does give a little strength to Senator Case. And we want to make sure that actual language is given.

Mr. Jenkins, what do you yourself think about a larger program provided in the legislation?

Mr. JENKINS. For a larger program?

Senator ANDERSON. Yes. Specifically let us state a million gallons now. Specifically the proposal that a million-gallon plant of some type—I use Ionics only because they testified on a million gallons—to meet the desires that Senator Case outlined for a larger plant in the north Great Plains area than the present plant which was used at Phoenix and Miller, S. Dak., and is now at Denver.

That is one phase of the program.

The other phase is the fact that work has been done at Harbor Island. It is promising. It is very encouraging. And at least 3 firms, and probably 20 firms—but at least 3—we will say, stand ready to go ahead very quickly.

Dr. Badger was sure he could go ahead. Maxim Silencer and Griscom-Russell stated they were quite ready to go ahead on about a million-gallon capacity at somewhere in the neighborhood of between a million and two million dollars after the site was prepared.

Do you think that sort of a program is desirable and necessary at this time?

Mr. JENKINS. You have asked two questions. May I answer the first one first?

Senator ANDERSON. Take the Great Plains first.

Mr. JENKINS. I believe you asked if I thought that a larger program was necessary. I believe that, as a former member of the President's Cabinet and head of one of the greatest research organizations in the world, the Department of Agriculture, you know that the bureau heads and division heads, office heads, and section heads, all feel that their work is more important than other people's work and that they want it to go faster than the overall policy of the department and the administration will permit.

They wouldn't be good employees unless they were enthusiastic about it.

Therefore, my answer to that part of your question is I have always thought that we should have a much larger program. But Congress didn't authorize a much larger program. We are trying to do the best we can with what we have.

Now, as to the second question.

Certainly a real pilot plant on brackish waters in the Great Plains would produce valuable engineering data that we do not have. However, I have felt with regard to the installation of an existing piece of equipment, such as has been developed and perfected by Ionics that very little would be gained by building a million-gallon plant, except for one thing. That process does have—and several of the other processes that we have helped to nurse along do have—high costs at the present time partly because they are not in what might be called mass production.

The cost is high because each piece of equipment is tailor made. And no one will place a large order because the cost is high. This isn't new.

It is a paradox that has occurred in many things—color television is one—and someone has to make the sacrifice and order a big plant of some kind.

And that helps the factory or the industrial concern to lower its prices. If that were to be done, I am sure that the Ionics equipment would be sold for much less than it is today.

Now, I don't know whether that is a good thing for Government to enter into.

Senator ANDERSON. How many times is this going to have to go ahead?

Mr. JENKINS. This is a policy not a scientific problem. It is a problem in Government policy, it seems to me.

Senator CASE. Mr. Chairman, this morning we had some testimony which you weren't privileged to hear from four generators people of Trenton, N. J. And our witness there suggested that what was the equivalent of a breakthrough was achieved by the employment of certain standard units that were already in production.

But by a combination of them and by virtue of a special heat transfer surface, they were able to get a significant economy in output.

Now, I am not sure when we look at a process and we say this is a pilot plant merely because it proposes to employ something which has not been made on standard patterns, whether we aren't just crippling ourselves here by semantics.

If a breakthrough can be achieved by taking a combination of units which are in standard production and by using them in the sizes at which they are available and have demonstrated capabilities, we get a much larger plant. But by the nature of the combination we achieve a breakthrough and we ought not to be foreclosed from considering that type of a plant either.

Senator ANDERSON. I agree thoroughly. That is why I wanted to have the Secretary express himself. Because if it is his feeling—and I have no question of his right to feel that way—because there is some history that is pretty compelling—but if it is his feeling that linking together four units of a device in order to get up to where you can test it takes it out of the pilot-plant stage and puts it into the demonstration stage, then we have to have new legislation.

Because that is what you have to do next. That is the one thing that has got to be done next if we are ever going to learn anything about this process.

As long as we stay in a little hand meat grinder, we are never going to find out what can be finally worked out.

And I do think that the proposal that Senator Case is interested in—we would like to find out what would happen if we fed a million gallons to this.

Mr. Jenkins said we have helped nurse this along. I don't question that too strenuously, but I say to you that one little unit put on the back of a trailer of some kind that runs a few hours at Miller, S. Dak., doesn't give much answer to the Senator from South Dakota, who would like to know how you can change the brackish water in the State.

And we would like to see somebody plunge in now. I am just trying to find out before we get this hearing closed whether we do have to have legislation. Because if we do have to have it, then the Senator from South Dakota and I are going to have to stand on the floor of the Senate and say we have to have it because.

And that is the reason.

Now, you have answered the Ionics membrane part here.

What about the situation with Dr. Badger with which you are familiar? He has a plant at Harbor Island. You were here I believe yesterday afternoon when he testified that he was not alarmed. He believed he would solve the problem of scale and he believed he would solve several other problems and he believed he would go ahead and build one up to this size of a million gallons.

He said frankly that wasn't going to give him a cost of 30 cents. It was going to give him a cost of maybe, 90 cents. But it was going to give him a step in the right direction.

He was very sure he could go ahead and do it. Then came Mr. O'Leary of Maxim Silencer who built some things and he said we know what we have. We know what we can do. We are sure of it. And he had, as I remember it, a figure of about 88 cents for the same sort of a general operation that Dr. Badger had 90 cents for, indicating at least there was some harmony in their viewpoint that a very forward looking step might be taken in this field looking toward a final plant someday that would produce this at low cost.

Now, another thing that struck me as very much worthwhile was that if such a plant were to be built, let's say with one process on the Pacific coast and another plant with another process to be built maybe in the northern part of the eastern coast, and a third process that looked promising might be built in the southern part of the eastern coast, or something of that general nature—so that we have different kinds of them—it did strike me that people who were interested in this might visit those various plants and see how they were coming.

You might go to Los Angeles or New York or some other place and take a look at one of these plants and might become interested. Scientists have a funny way of looking at these things and saying "I can improve that." Then we began to make headway.

What do you think about the other plants? The Badger plant?

Mr. JENKINS. We not only feel that the Badger long-tube vertical plant should be put into a large pilot plant stage of about a million gallons a day, perhaps as the next step. We are actually planning to do that under the present program.

Senator ANDERSON. That you think is a pilot plant, a million gallons a day?

Mr. JENKINS. Yes, sir.

Senator ANDERSON. Do you agree with that, Mr. Secretary?

Mr. AANDAHL. Yes; I do. I am very much interested in seeing that next step taken which involves about a million-gallons-per-day production. And I am thinking of it as not only limited to the Badger plant but any other plant that seems equally promising.

Senator ANDERSON. I am not trying to limit the Badger plant either.

I am using that only because we were both familiar with what we were discussing.

Have you had any indication from the Appropriations Committee of either Senate or House, as to whether they consider that size a pilot plant? Have you been up before them and presented such a suggestion? Have you had any comments from them?

Mr. JENKINS. Yes. There has been no objection there as far as the proposals which we have made which have been for the engineering work.

Senator ANDERSON. The engineering work. I don't want just engineering work. I want to build it.

Mr. JENKINS. There is remaining in our present authorization enough money to build that 1-million-gallon plant of Badgers if we use a major portion for that purpose.

Senator ANDERSON. Yes. But you see we don't use the same language. You say there is enough money in the authorization. I want to know how much money is there in the appropriation.

Frankly, you just can't eat the authorization at all. You have just got to have the money shoved at you in the appropriation bill.

Mr. AANDAHL. I think, Mr. Chairman, I can say that the record indicates that we have had some difficulty in getting appropriations even for the small pilot-plant operation.

Senator ANDERSON. I agree.

Senator CASE. In the plant of the type we had presented this morning, it was suggested that a 16-million-gallon-per-day plant was the one which by the nature of arrangement and by the utilization of certain standard items achieved what was the equivalent of a technical breakthrough. Would you say that if that assumption is correct, that that would be a pilot plant?

Mr. AANDAHL. I would have to look at that a second time.

Senator ANDERSON. Yes; that is fine. I mean, I want Senator Case's question answered. And will you submit for the record after you have had a chance to consider it and had a chance to go back and look at the material upon which his question is based, an answer as to whether you think that could be done within the pilot-plant language we now have? I don't want to crowd you.

Mr. AANDAHL. Which process are you referring to?

Senator CASE. The one referred to by Power Generators of Trenton, N. J. He presented it in some detail. And it is presented in here. But this sentence illustrates:

> **The attainment of economic saline-water conversion requires a major technical breakthrough. A 16-million-gallon-per-day, PGI plant in figure 2 is based upon a new thermodynamic concept.**

I asked him at one point whether or not that could be in a smaller unit. And he said, you lose part of the advantage of using these standardized pieces of equipment.

Mr. AANDAHL. Do you have an estimate of cost of that?

Mr. LARRECQ. We have an estimated cost as of now based upon the 16-million-gallon-per-day plant which is $1.05——

Senator ANDERSON. I mean total cost.

Mr. LARRACQ. About $25 million for the 16-million-gallon-per-day plant.

Mr. AANDAHL. The answer is: We definitely need changes in our authorizing legislation to proceed in that way.

Senator ANDERSON. My point in the question, Mr. Secretary, is this: We have not tried to choke anybody off from making an expression of opinion in this hearing. Yet, if we got to the floor of the Senate and somebody stood up and said, "Well, here is a letter from the Department of Interior saying they can do all the things you want done within the present framework of the existing legislation; why do you need the new legislation?"

It struck me we had better amplify this a little bit and examine this point.

Mr. AANDAHL. I am sure you understand, Mr. Chairman, that our position has never been that we can do everything that you might have in mind or other members of the committee might have in mind. In my paper I outlined certain steps that I thought were very important in proceeding with our work on the saline-water program. As far as those steps I outlined were concerned, I felt we could do them quite well under the present authorization.

Now, you may have a program that goes somewhat beyond that. And I don't want my statement to be interpreted for a moment as being that we can do everything under the present authorization that you or the other committee members may have in mind.

Senator ANDERSON. Yes. Well, you may recall the letter that you signed which you sent on February 4, 1957, which dealt with the Virgin Island situation. And in that letter you brought out that Mr. Aspinall had raised in the House that restricted and forbade the building of such a plant in the Virgin Islands by the demonstration terms.

I don't quarrel with what you said.

Mr. AANDAHL. Yes; that was interpreted entirely as a demonstration plant.

Senator ANDERSON. Yes; which it is. But when you get up to 16 million gallons it is a production plant pretty closely. It is a small one.

Mr. AANDAHL. You are getting into a plant of the size and the amount of money involved that goes beyond anything we have in our present authorization.

Senator CASE. I would like to ask the same question, but approach it from a slightly different angle.

Mr. Secretary, would you feel that without additional legislation that you are under any compulsion either directly or indirectly under present law to present to the Bureau of the Budget, defend there, and to defend before the Appropriations Committee of the Congress, a request for funds to acquire or create plants of the type that the chairman has been discussing?

Mr. AANDAHL. Well, I have rather felt that the appropriation authorization of $10 million is really a goal that we should work toward. That is, we should do the best possible pilot-plant testing and experimentation and research that we could with the expenditure of the full $10 million. I think the Congress definitely felt we should do that much.

And we had that in mind when we prepared the 1958 budget asking for $1,159,000 which was approximately the annual pro rata share of the total amount of money. It was slightly less, but we expected that we would get the peak of expenditure a year or two later.

In 1959 we didn't go quite that far because we were preparing our budget under 6 or 7 months ago, a somewhat tighter budget situation.

Senator CASE. Did you contemplate in the preparation of either the 1950 or 1959 budgets, or would you propose now in development of your 1960 budget, to ask for and defend plants of the size the chairman has been describing without the support of additional legislation and a recommendation from the committee in the form of committee reports?

Mr. AANDAHL. I would say that the starting point in the Office of Saline Water, and in my position as Assistant Secretary, would be to try to get the annual pro rata amount of the remaining $10 million in the next appropriation.

And the larger pilot testing operations, as I see them, would be in the range of about a million gallons per day.

Now I am not sure how far we would be able to go with that standard of appropriation request. It would have to be harmonized with the overall budget problem. But as far as a starting point in the Office of Saline Water and in my position as Assistant Secretary, that is what we would start out with as our goal.

Senator ANDERSON. I only want to say, Mr. Secretary, that while I recognize it has to be harmonized with the overall budget program, I do remember that I recommended a great deal more money for research on agricultural products when I was in the Department than was generally requested or even granted at that time. I tried to point out that unless we found new uses for certain agricultural products we would have surpluses in the next few years.

I have lived to see those surpluses.

Now, if we don't find some way of supplementing our present water supply, the State of California—Mr. Harvey Banks is here—will tell you that it has got $11 to $12 billion worth of projects that it is going to be interested in some of these days.

If we solve some of these problems I believe we might eliminate some of the necessity for some of the development of water that California now visualizes.

They may need it all when they get through. But certainly we could have some money that we will spend in perhaps expensive irrigation projects if we had the availability of unlimited supplies of sea water that lie right beside these great metropolitan areas.

Would you, in view of all this discussion, review this part of the hearing again before we print our final hearings and submit for the record any comments you have to make on these questions of expenditures and any softening of the words that you have with reference to Senate Joint Resolution 135 and the bill of Senator Case, if you do believe at some later date that a million gallons a day might be required?

Mr. AANDAHL. May I comment that I didn't interpret those words as being very rough.

Senator ANDERSON. I didn't either.

We are not far apart. You are as anxious to help this program along as I am. And, Secretary Seaton is also very anxious to help it.

I am worried, frankly, Mr. Secretary, that someone may find that language in the report and misinterpret your motives and the motives of the Secretary of Interior. Whereas if we did recognize, as some

must feel, that 2 or 3 plants of a million gallons a day capacity may be constructed and might make very, very advantageous contributions to the whole program and that in the situation of Senator Case where he has a very deep desire to do something on this brackish water situation and in which I join him, that there we might want a plant of sufficient size operating continuously over such a long period of hours that it becomes almost a demonstration plant but not a pilot plant and we wouldn't want you to run afoul of the previous discussions taking place on the part of Congress.

Would you, therefore, review the entire situation from that standpoint and see if you can give us any additional testimony.

Mr. AANDAHL. I will be very glad to do so. And even at the moment I want to call your attention again to the last paragraph of the letter reporting on the bill. Which does not entirely foreclose the possibility of some——

Senator ANDERSON. No.

Senator CASE. I think it offers enough encouragement.

Senator ANDERSON. I want to give you a fine chance to assert all your fine motives.

(The following communication and statement was subsequently received:)

LETTER FROM THE DEPARTMENT OF THE INTERIOR

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D. C., March 28, 1958.

HON. CLINTON P. ANDERSON,
Chairman, Subcommittee on Irrigation and Reclamation, Interior and Insular Affairs Committee, United States Senate, Washington, D. C.

DEAR SENATOR ANDERSON: In accordance with your request of March 21 at the close of my appearance before the Senate committee hearing relative to the saline water program, I have reviewed the situation again and wish to submit the enclosed statement which I will be very glad to have you make a part of the record.

Sincerely yours,

FRED G. AANDAHL, *Assistant Secretary.*

REVIEW STATEMENT ON SALINE WATER PROGRAM BY FRED G. AANDAHL, ASSISTANT SECRETARY, DEPARTMENT OF THE INTERIOR

In response to Senator Anderson's request, I reviewed the entire situation relative to pilot plants and demonstration plants for the saline water conversion program. In addition to the transcript of the Senate hearings and our information in Interior, I spent the entire day of March 25 with the Secretary's Advisory Committee on Saline Water Conversion. There were six members present with broad technical background and representing areas from coast to coast.

It is apparent that during the past few years outstanding achievement, both under the Federal aid program and privately, has been made in developing processes for saline and brackish water conversion.

The Office of Saline Water, in addition to conducting much basis research, has placed a few processes under initial pilot plant testing. These tests have been most encouraging.

As the Senate committee apparently so well recognizes, the public interest and the urgent need for water in some areas direct that this promising outlook be expeditiously carried through to fruition.

The immediate need, as I see it, is to put more of the promising processes under initial pilot plant testing and a few of those that respond the best in larger followup pilot plant testing. Some processes will require fairly large plants for the initial test.

Pilot plants are basically to explore, to test, and to uncover methods of improvement. In the more advanced stages, however, they carry an appreciable amount of demonstration value. I would like to see the plants built under

the Department's program continue to be called pilot plants. I think such designation is more descriptive of our present task and the connotation to the public more in line with what we should be doing.

The existing legislation authorizes us to proceed with this program, although it must be recognized that both the money and the time limitations of that law would soon be inadequate to continue in the larger pilot-plant work.

If it is the decision of your committee to give greater impetus to and accelerate larger size testing of processes in the saline-water program by legislation such as Senate Joint Resolution 135 or S. 3370, I wish to make the following suggestions:

1. The plants be called pilot plants.
2. The law authorizes plants instead of 1 or 2 plants. (Several 1-million-gallon-per-day plants might be much more helpful to final accomplishment than two 5-million-gallon-per-day plants or one 10-million-gallon-per-day plant.)
3. Provision for administration as well as construction and operation of the plants should be stated in the act.

Senator ANDERSON. I have a wire from Badger Manufacturing Co., of Cambridge, Mass., that they will file a prepared statement and submit it by mail. I understood that Mr. Sandell, of the Carrier Corp., is also filing a statement to be printed in the record.

(The statements referred to are as follows:)

STATEMENT OF JOHN J. CAMPOBASSO, BADGER MANUFACTURING CO.

I appreciate the opportunity afforded me to present a few remarks in support of Joint Resolution 135, providing for a full scale demonstration plant for the conversion of sea water to fresh water.

The Badger Manufacturing Co., with whom I am associated, has been a leading producer of sea water distilling apparatus for many years. In addition to the production of several thousand standard vapor compression, distilling plants for both shipboard and land based use, this compnay has devoted considerable time and energy to research and development work intended to improve the quality and widen the scope of this type of equipment.

Currently our research work is progressing in several fields among which are improved types of vapor compression distillers for atomic submarines; improvements in low pressure, flash type evaporators; a development of the Badger-Hickman rotating evaporator; and research and development in the low temperature, recirculation, vapor compression type. The three latter types are all destined to play an important role in the desalting of sea water in quantities such as would be required for municipal, industrial, and agricultural use.

Based on present knowledge of sea water conversion methods, a full scale demonstration plant as outlined in Senate Joint Resolution 135 can be successfully constructed and operated. Full scale sea water conversion plants are now in operation in other parts of the world, some having a capacity of as much as 1 million gallons per day.

Such a plant constructed in this country at this time would serve to demonstrate the excellent progress made in the research and development phase of this program during the past several years. A full scale plant is now essential to the continuing progress of this work because it would serve to help solve many technical and operational problems as well as serve as a yardstick to realistically measure costs of producing fresh water from sea water. No one will deny the need for this information since we have all run into estimates of cost of water that vary from 20 cents to $1.50 per thousand gallons. The construction and operation of this plant in a water shortage area would represent a great advancement in this field and we favor enactment of this proposed resolution.

However we wish to advise that this does not represent a major breakthrough in our quest for a solution to the overall sea water conversion problem and we feel that considerable basic research must still be undertaken before this most important task can be completed.

STATEMENT OF DEWEY J. SANDELL, DIRECTOR OF RESEARCH, CARRIER CORP.

In reply to your invitation to representatives of industry to attend this hearing and to present views of an active program to meet economical demonstration goals for the three outlined objectives, I am privileged to express our general feelings and questions on the approaches to the saline water conversion problem.

First, and most importantly, I should like to acknowledge the program being sponsored by the Department of the Interior and administered by the Office of Saline Water. The objectives are sound and progress is according to their long-range plan. Projects are approaching quite rapidly the stage in development where a logical evaluation can be made. The major criteria of their program are to find and develop processes which have not only a technical feasibility to convert saline or brackish water to fresh water but also possess an economic potential of performing this operation at a cost that is competitive or practical for utilization by industries, metropolitan areas, irrigation, etc. The technical fundamentals involved in most processes under investigation today are old, however the actual costs for their utilization have been too high. Therefore it is advantageous to conduct vigorously research and development phases on the various processes to investigate and utilize new materials, new techniques which will improve the efficiency of each process to reduce the costs of the product water.

This approach is basic to most research and development programs. It follows a standard pattern and logical progression.

(1) Preliminary investigation, analyses, and literature review of proposed ideas;

(2) Design and fabrication of experimental apparatus to determine technical feasibility;

(3) Development of a laboratory working model;

(4) Design of pilot plant;

(5) Construction and test of pilot-plant operation.

Concurrent with steps 3, 4, and 5 above are conducted continuous economic and technical evaluations of the process. If the results show promise, the next step is begun; if not, modification or new ideas must be developed or the project dropped. Our definition of a pilot plant is a scale of operation which provides results indicative of performance of a system in its actual commercial application.

(6) Design, fabrication, and operation of a production scale plant.

The developmental progress on the conversion program has followed these steps. If specific applications for saline or brackish water conversion do not include the necessity of low cost (below $1.50/1,000 gallons) it is certainly feasible to assemble a refinery for large production capacities now. Several such installations have been or are in process of being constructed in areas of critical need. Demonstration has been established but not at a promising competitive cost.

A second point which is related to the objectives, approaches and timing of any saline conversion program implies the need for answers to a number of questions or review of present status. What is the major need for additional water supplies? Where? Their urgency? What is a competitive cost? Are electrical or heat energy sources available? Answers to these questions might well indicate parallel long- and short-range approaches to be needed to solve the problems.

Third, a method to accelerate the rate of progress in the processes under investigation is to provide additional funds for pilot plant evaluation of those that show promise of meeting the major objectives. Only after results are obtained from these pilot plant operations can the true economic evaluations and comparisons be made for selection of preferred processes to meet specific requirements. Such pilot plants should be of large enough capacities to enable good educated guesses to extrapolate costs to production facilities. At this point I should like to remind the subcommittee of a quite similar technical progression of developments—the field of commercial utilization of nuclear power. In the very early stages of development of reactor designs, optimistic estimates indicated competitive power costs would be available from nuclear reactor designs within 3 to 5 years from an active construction program. Actual experience,

however, has resulted in costs which are 2 to 10 times those estimated. Now a retrenching is in progress with accelerated effort on research and development projects to improve the technology and its application to enable improved efficiencies, and thus economic compatibility.

Lastly, we would recommend a continuous, careful evaluation of estimated costs for each of the processes under investigation. This relative measure will assure no overoptimisim at too early a date, and also separate out those activities which do not show promise of meeting the objectives. The standard form of the Office of Saline Water is a step in this direction.

Summarizing, we urge a review of the objectives of the saline water conversion program. If there are urgent needs to fulfill immediately a production requirement which will not be influenced by low, competitive costs, then selection can be made of plants which are available off the shelf and have demonstrated their technical feasibility. If the twofold objectives of economic as well as technical feasibility remain utmost in consideration, then increased funds should be made available for the progression of R. and D. steps through pilot plant stages. At this stage, selection of the better processes can be made for further exploitation to meet specific production requirements.

It appears evident that the first 2 specific areas of the 3 approaches outlined for this hearing are vitally dependent upon economic compatibility and, although the need is quite urgent, any process chosen for demonstration must have produced the results from pilot plant operations to assure successfully meeting the objectives. If not, the future program and progress could easily be decelerated instead of accelerated.

Attached for your information is a brief description of the carrier direct freezing process. Our present status involves the design of a pilot plant. It is not in a position to be a candidate for a multimillion-gallon-per-day production facility today. However, we feel it has real potential for the future, and after pilot plant evaluation will be a strong competitor for the saline water conversion requirements.

Carrier Direct Freezing Process for Conversion of Saline Waters

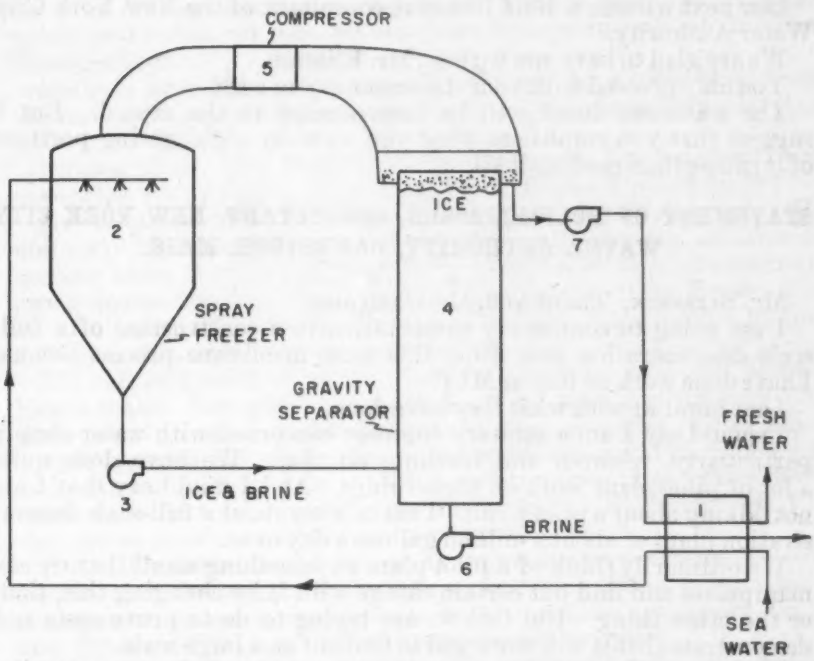
Our process, as simply shown on the attached schematic, depends upon the basic principle that a saline solution can be separated into its individual components by decreasing the temperature of the solution sufficiently to provide partial freezing. For sea water, a reduction in temperature to 28° F. will yield a mixture of ice crystals and concentrated brine. Fresh water is obtained from separation of the crystals from the brine and melting them. The minimum energy requirements to freeze a pound of ice at 26°–28° F. is 150 B. t. u. as contrasted to 1,000 B. t. u. to vaporize a pound of steam from saline water. In order for the freeze process to take full advantage of this 1 : 7 ratio, it is essential to keep heat losses and actual energy requirements for freezing and separation processes as near to the minimum as practical.

A brief description of the direct-freezing process with reference to the schematic will provide an explanation of its potential to meet the economic goal, namely $0.50–$1.00 per 1,000 gallons, established by the United States Department of the Interior.

This freeze-separation process uses a simple and novel method of refrigeration. Sea water (35,000 parts per million) that has been precooled (1) is sprayed into an evacuated chamber (2). In this direct freezer, a small quantity of water is evaporated. The evaporation extracts heat from the saline solution and causes ice crystals to form. The slurry of ice and brine is pumped (3) to a separator (4). The water vapor which results from the flashing of the solution upon entry into the evacuated (3.4 millimeters mercury pressure) direct freezer is compressed (5). The discharged water vapor is condensed to water on the ice surface at the top of the separation column (4). An alternative to the compressor is an absorption system to remove this water vapor. The water can then be recovered by separation from the absorbent.

Due to the density relationships of ice and brine, the ice floats to the top of the gravity separation column (4) while the concentrated brine is pumped (6) through a heat exchanger (1) back to the sea or waste. Since brine adheres to the surface of the ice crystals, a small amount of fresh water is added at the top of the separation column to provide counterflowing washing of the ice as it floats upward within the column. The product ice is melted at the top of the column and pumped (7) through a heat exchanger (1) to storage.

SCHEMATIC FLOW DIAGRAM
CARRIER DIRECT FREEZING PROCESS



The process has been experimentally evaluated on the basis of a 300-gallon-per-day fresh-water capacity at the Carrier Research Laboratories, Syracuse, N. Y. The work has been done under contract to the Office of Saline Water, United States Department of the Interior. At the present time, we are performing a design study for a pilot-plant facility to produce 10,000–25,000 gallons per day, utilizing the direct-freezing process.

The cost to produce fresh water by this process from sea water and brackish water has been estimated, using the standard procedure of the Office of Saline Water. On the basis of extrapolation to a 100,000-gallon-per-day capacity, it appears feasible to obtain the fresh water at an operating cost (energy, amortization, taxes, interest, etc.) of approximately $1 per 1,000 gallons. Guesstimates have indicated at greater capacities (approximately 10 million gallons per day) the operating costs may be reduced to within the range desired by the program objectives.

Until pilot-plant operations give results from actual runs on a basis of continuous, larger capacity productions, it will be extremely difficult to evaluate or contrast the technical and economic feasibilities of the several conversion processes which are under investigation to provide fresh water within a range of costs competitive to natural-water supplies.

Senator ANDERSON. We will finish the hearing this afternoon and I will sit long enough to accommodate all the witnesses.

Senator Case has just referred to this presentation by Power Generators, Inc. He has called my attention to the summary which makes a fine statement.

By virtue of the successful demonstration of a unique heat-transfer surface, as also by virtue of the employment of the latest type prime mover within an optimum thermodynamic framework: it is now, for the first time possible to envisage economic desalinization of sea water and economic reclamation of potable waters from industrial and municipal effluents.

As we go on and continue to work with this, we continue to get encouraging statements that lead us to believe that industry thinks this is possible and I think it is possible and we are glad to have the encouragement.

Our next witness is Rolf Eliassen, consultant of the New York City Water Authority.

We are glad to have you with us, Mr. Eliassen.

You may proceed with your statement as you wish.

The statement itself will be incorporated in the record. But I suggest that you emphasize what you want by highlighting portions of it rather than reading it all.

STATEMENT OF ROLF ELIASSEN, CONSULTANT, NEW YORK CITY WATER AUTHORITY, CAMBRIDGE, MASS.

Mr. ELIASSEN. Thank you, Mr. Chairman.

I am going to confine my presentation to a construction of a full-scale demonstration unit using this ionic membrane process because I have done work on that at MIT.

I am familiar with what they have done.

I should say I am a sanitary engineer concerned with water supply particularly, research and teaching on that. We have done quite a lot of pilot-plant work on these things. And I might say that I am not talking about a pilot plant. I am talking about a full-scale demonstration plant of about a million gallons a day or so.

We ordinarily think of a pilot plant as something small that we can manipulate and find out certain things with it by changing this, that, or the other thing. But this we are trying to do to prove costs and demonstrate that it will work and to find out on a large scale.

There are so many things engineers cannot get from small pilot plants when they start finding out costs.

Now, the significance of saline water to me is extremely important because more and more we are going to have to rely on that. I have included here two of the finest things that have come out of this survey. I was glad to see out of this saline water program these surface water supply areas which have very high salinities.

You will notice they are confined mostly to the Dakotas and to Oklahoma, Texas, New Mexico, and Utah. And then you find them again—well, there is only one little note there on the side opposite Chesapeake Bay. It says: "The volume of saline water in coastal areas is virtually unlimited."

"Almost unlimited," it says.

Figure 2 shows the wells that have disclosed saline waters. And you will find them almost all over the United States. These dots, circles, and numbers. So that there is no question about where this is to be applicable in the future.

It is going to be useful. And the point I would like to bring out is that the Department of Commerce has made a survey of the future water supplies. And within the next 25 years they claim that we are going to have to go from 160 billion gallons per day to 315 billion gallons a day.

Senator CASE. Practically double.

Mr. ELIASSEN. Yes, sir. And where are we going to get that water? That is the question. And it seems to me that these additional supplies have got to come from some of these brackish water sources as well as from the development of many of the other supplies not now developed. But to double our water supply for irrigation public and industrial uses, we are going to have to look into many of these methods.

Methods have been looked into, I must say, on a pilot-plant basis. We have got to prove costs, prove the thing on a large demonstration basis.

Senator CASE. You think the large demonstration basis will produce what result that we do not get from the small pilot plants?

Mr. ELIASSEN. We shall have the engineering of this plant. The units will be larger than those presently used. But the actual engineering costs, the process control, the cost, let us say, of membrane replacement—we don't have those figures now on these larger units. We don't have—for the smaller units, the piping, the pumps, motors, and things like that, they are almost the same.

We call it hardware. It is about the same as it would be on a larger scale. But you have to find out by working this how does it do this. I happen to be chairman of the committee of the American Water Association on the water conditioning and corrosion control. And one of our jobs is to find and to prove these newer developed methods to the waterworks there and to either disclose that they are no good or that they are very good.

But the waterworks profession is by nature very cautious. Some say they are lethargic. But that is not true. Their responsibility is too great on producing potable water for their consumers day in and day out. They can't afford to experiment too much.

Now, they will accept something if it has been proven on a demonstration scale, not on a small scale.

I mean have confidence in design, the process control, the operation, the maintenance costs and the quality of the water produced. Those are the things which we must show in a method of this type.

Now there are other sources—one thing that a lot of the waterworks press says, is that this is applicable to a small section of the country. That is not true, as I showed on these maps which the Bureau of—rather the United States Geological Survey produced. Because I happen to be a consultant—member of a board of consultants of the Board of Water Supply of the City of New York. We have tapped our last mountain source there now. And we are starting to look for other means.

I have an assignment now from the chief engineer to find out what to do.

We abandoned—I was in on a court case there abandoning a supply of 30 million gallons a day within the city of New York because it was too brackish. People didn't want to drink it. We couldn't afford to give up 30 million gallons a day because they had water-conservation programs—bathless Thursdays they used to call them in the newspapers, to try to conserve water. But still it is true there, it is true in Atlantic City. It is true in many other parts of the country where we can get both the surface and ground water supplies.

23642—58——13

There are a number of sections in the country then that this would be applicable to. Engineers are going to be forced to adopt these later and better demineralization techniques.

Senator CASE. Your observation growing out of your experience as chairman of this board of consultants——

Mr. ELIASSEN. I am not chairman, I am a member of the board.

Senator CASE. Would you say this problem is not one just of the west coastal cities, or of the inland areas, where they have brackish waters but, is also a problem of the larger cities in the East?

Mr. ELIASSEN. Very definitely there are a number of places where we have that situation of brackish water. On Long Island the places, the biggest consumers of water were Long Island. Around the Houston, Tex., area is another big area where salt water encroaches.

Senator CASE. If you had had a solution to this problem of saline water, would you have been able to recommend perhaps against the abandonment of this saline supply of 30 million gallons that New York City had to give up?

Mr. ELIASSEN. Yes, sir; I would have. As a matter of fact yesterday the chief chemist was in my office at MIT. We were discussing this. Because they just shut down some other wells for the city of New York. They are cleaning out a big pipeline from the Catskills. They have to use their well supplies and people don't like the taste. They are used to the others.

And I am going to make a study to try to make them cognizant of it now. I might say that for the very immediate future the problem has been solved because they have just put in a new dam. But looking ahead, they are going to catch up with us before too long. That is our problem—looking ahead.

There are a number of things that the waterworks profession already knows. We do know that this Ionics membrane process has shown itself to be absolutely the cheapest process for the securing of brackish water, not for sea water, but for brackish water. The cost figures are down in the range below 50 cents or around there. That has been proven already.

I think that other economists can come out of this proof. I think also that the waterworks profession would follow a demonstration plant with a great deal of interest and would, of course, give it publicity which it should have so that the people would know about it. Not only this, but any evaporation plant or any other thing like that. Because we, in our water resources division, have been considering time and time again, new sources of water, how are we going to make up for the increasing demand and decreasing surplus of the water supplies?

One other thing to finish up here was consideration.

One of the big power companies out West and also we, are going to study this for New York, was this sheet that I had here made up for figure 3, there.

The gentleman who preceded me had a nuclear powerplant which had distillation. Well, a steam powerplant can also be used for this—and also of course is used. Now you can bleed off low pressure steam for multiple effect evaporators. That is what is meant to be shown there. But you are better off if you can produce steam and use those evaporators at a constant rate to get maximum efficiency.

But the powerplant as you know, they have the peak load, comes in the middle of the night—6 to 10 or so—and you have offpeak power. Now that offpeak power could be used for the generation—that steam could be used to generate electric power which in turn could be used to extract water, fresh water, from brackish water, while the other one worked on sea water.

I have just shown one schematic thing here. This is something that the Virgin Islands could do if they needed power, if they needed water to operate their powerplant at maximum effectiveness all the time; to operate the evaporators at maximum effectiveness; to use the surplus power for demineralization by this electrical method.

I have a few conclusions here which I should like to read very briefly.

Evidence is plentiful and irrefutable that a tremendous growth in demand for irrigation, public and industrial water supplies will take place during the next two decades.

Two: This demand will force water users to tap the vast sources of saline waters in this country. The same holds true for many other parts of the world.

I might also add that as they tap those saline water sources their concepts of cost of water is going to go up some. Now, we are seeking the cheapest sources of water. But the cheapest have been used. We have got to go a little higher in our sites.

Three: The Ionics membrane process here is a combination and engineering reality on a small scale. I have seen it myself.

Four, Before being widely accepted as a logical answer to the saline water usage problem, by the engineering profession, and water authorities, the process must be proven by a full-scale plant in the million-gallons-per-day range of capacity.

Five: To me, this Senate Joint Resolution 135 is a rational proposal for proving this process—proving it in the manners that I have described costwise, engineeringwise—and eventually making it available to solve the critical water shortages which lie ahead for this country.

Six: This joint resolution attacks a problem which is desperately in need of solution, namely, how best to make available the vast saline water resources of this country.

Seven: To me the immediate present is the time when a full-scale demonstration plant of this Ionics membrane process should be constructed and operated, because the answers which the plant will furnish are needed right now.

It is going to take 2 to 5 years of data to sell the engineering waterworks profession on any process which we are developing.

Eight: For the next 20 years, public-works construction programs will be carried out in order to get a doubling of our water-supply facilities.

The need for effective means of increasing the water resources upon which public-works engineers can draw is of paramount importance to the economy of this country.

Senator Case. Thank you very much, Mr. Eliassen. Your full statement will appear in the record. And we will attempt also to reproduce these maps that you presented.

I think that you have made one point which needs to be recognized. And that is that before the people who are in the waterworks business can accept the responsibility of making recommendations to munici-

palities or other water districts with respect to plants that they need to have plants in operation of a size that will give them the operating experience as well as design costs to warrant a municipality going ahead with financing that would be necessary to put in such a plant or adapt it to a particular community's needs?

Mr. ELIASSEN. That is correct.

Senator CASE. Thank you very much.

(The maps referred to were unsuitable for reproduction and are on file with the committee for reference purposes.)

(The statement referred to follows:)

PREPARED STATEMENT OF ROLF ELIASSEN, CONSULTANT, NEW YORK CITY WATER AUTHORITY, CAMBRIDGE, MASS., ON THE SALINE WATER PROBLEM OF THE UNITED STATES

I. GENERAL BACKGROUND

A. Joint Resolution

This presentation will discuss Senate Joint Resolution 135 introduced in the Senate of the United States on January 9, 1958, by Senator Clinton P. Anderson of New Mexico. Further, this presentation will discuss the need for and advantages of constructing a full-scale demonstration using the ionic-membrane process for the demineralization of saline or brackish waters for ultimate consumptive use. It should be stated from the outset that the writer believes that this joint resolution is a rational approach to a serious problem which this country must face right now.

B. Significance of saline water

The saline water conversion program of the Department of the Interior which resulted from hearings before this Committee on Interior and Insular Affairs in 1951, has attracted the attention of economists, governmental agencies, engineers, and business leaders throughout this country and many parts of the world. Research has been conducted on a broad scale, financed in part by funds from the Federal Government, and in part by venture capital, on means for the economical extraction of salts from saline or brackish waters. Some of the processes have been proven on a pilot plant and relatively small consumptive scale. In order to bring this program to the attention of the water works profession of engineers, management and governmental authorities, it will be necessary to prove the engineering and economics by a large-scale demonstration plant in an area where saline water is a problem, and where it exists in sufficient quantity to become a reliable source of water supply for consumptive use after extraction of most of the salts.

The existence of vast quantities of saline water reserves has been shown in the water supply paper No. 1374 of the United States Geological Survey entitled "Preliminary Survey of the Saline Water Resources of the United States." This long paper, which was published in 1957, is a valuable contribution to the saline water conversion program of the Department of the Interior and is the best general document of the need for considering saline water resources in the further development of the economy of this country. Some of the disclosures will be discussed later in this presentation.

The increasing sophistication of the industrial economy of this Nation is leading to the creation of more saline waters. The writer has been a consultant to several of the largest chemical companies in the country on matters pertaining to the disposal of industrial wastes. It is axiomatic that organic matter which will decrease the oxygen supply, give rise to nuisances, and destroy the fish life of streams, will be removed by chemical and biological methods of waste treatment. Research is continually being undertaken to develop more effective and economical means of destroying organic industrial wastes.

However, most of these wastes also contain mineral salts. It is very difficult and costly to remove these salts from waste discharge and as a consequence the salt concentration of streams has been building up in many of the industrialized areas of the country. It is a matter of known record that the Ohio River Valley Water Sanitation Commission has an extensive reporting system to "sound the alarm" when the saline concentration of the Ohio River and its tributaries becomes too high for the many water treatment plants which use these streams as their only sources of supply.

High rates of withdrawal of ground water supplies in communities along the Atlantic, gulf, and Pacific coastal areas has made many supplies too saline for satisfactory municipal use. The writer is a member of the board of consultants of the board of water supply of the city of New York. He participated in litigation which led to the abandonment of a saline supply of 30 million gallons per day from wells within the city, just when water shortages were at their peak and "Bathless Thursdays" were decreed as a matter of water conservation. If a reliable and economic method of water demineralization had been available at that time, it would have been possible to reclaim these waters and avoid the abandonment of a supply which had been satisfactory for many years but had become increasingly saline. The same situation is occurring in other parts of the country.

Thus, the saline water problem is significant from two standpoints: (1) The need for tapping the vast resources of saline waters to satisfy the growing water needs of many parts of the country, and (2) the threat of increasing salinity of many surface and underground water supplies which must continue to be used. The need for proving on a large scale that economical and practical methods of reclaiming theses waters for consumptive used is at hand, is becoming increasingly obvious.

C. Practical methods of demineralization of saline waters

1. *Distillation.*—The evaporation of water is a proven means of separating salts and achieving a virtually pure distillate. This process has a number of variations, many of which have been shown to be economically applicable to sea water. It should be recalled that the sea contains only 3.5 percent of salt and 96.5 percent of water. What distillation does is to work on the 96.5 percent and force it away by thermal energy, leaving the 3.5 percent as a residue. Actually, not all of the water can be taken off because the sea water is only reduced to a brine. As the water becomes less saline, a proportionately greater amount of water must be driven off for every pound of solids and the thermal energy required per pound of salts becomes increasingly greater. Accordingly, evaporation is best adapted to sea water. Cost of evaporation plants range around $2,500 per thousand gallons per day of capacity. Water production costs run around $2 per thousand gallons. Values above and below these have been noted in the literature.

2. *Ion exchange.*—The cation-exchange principle has been used for many years in water softening. This only substitutes sodium salts for calcium and magnesium, which cause hardness. Modern cation and anion exchangers have been developed to obtain complete removal of dissolved salts. Those units require regeneration by caustic soda and by acids which may run the costs up very high. Plants using ion-exchange principles have been built in very large capacities for normally hard waters. However, with saline water, the cost of regeneration chemicals becomes very high. Mere softening is not enough because it leaves the water more saline than previously because for every calcium ion there are substituted two sodium ions. Brackishness to the taste becomes a problem, as does the conductivity of the water and its effect on the corrosion of metallic pipes. No further consideration will be given this method for the solution of the saline water problem in this country in view of the high cost of the method.

3. *Electrodialysis by membranes.*—The most recent development in the field of water demineralization is the process making use of semipermeable selective ionic membranes. The important scientific contribution of this process is that it works on the salt, or smaller constituent, of the saline water. In other words, this process exerts effort on the smaller fraction to pull it away from the larger. Theoretically, it should take less work to pull 1 pound of salt out of 100 pounds of saline water than to try to pull 99 pounds out and leave the 1 pound behind, as must be done with evaporation. This process does lead to economies which have been proven on a small scale to cost about $1,000 per thousand gallons per day of installed capacity and to produce water at about 85 cents per thousand gallons when handling water with 5,000 parts per million of salinity. Greater economies are achieved as the water goes down in salinity. The same does not hold true for evaporation since there is no difference in the amount of work to be done in pulling the water out of the salt environment. An impressive list of some twenty-odd installations has been presented to your subcommittee by Professor Gilliland, one of my colleagues at MIT. You will have noted that no large-scale demonstration plant has been installed.

II. INCREASING DEMANDS ON NATIONAL WATER RESOURCES

Bulletin B. S. B. 136, published by the United States Department of Commerce in 1956, contained projections on the estimated uses of water in this country. Some of the values are worth citing to show the tremendous rate of increase of the water usage with which this country is faced. For instance, irrigation water usage in 1950 was estimated at 100 billion gallons per day, of which 18 billion gallons per day was ground water. In 1975 it is estimated that the ground-water use will have more than doubled to 44 billion gallons per day and the total use for irrigation will have grown to 170 billion gallons per day. Public water supplies were estimated at 14 billion gallons per day in 1950 and will amount to 30 billion gallons per day in 1975, with about 20 percent coming from ground-water supplies. Finally, industrial and commercial uses will have grown from 46 billion gallons per day in 1950 to 115 billion gallons per day in 1975. About 10 percent of this will come from ground water. The 3 categories of irrigation, public, and industrial water supplies will have doubled their total demands from 160 to 315 billion gallons per day in 25 years. Many of the parts of the country using water in any or all of these categories are already short of water. Where else can some of these additional supplies come from but the intelligent reclamation of saline waters wh rever they may be found?

III. EXTENT OF SALINE WATER RESERVES

A. Surface-water supplies

Reference is made to Geological Survey Water Supply Paper 1374, previously mentioned. To save time, it is only necessary to refer to plate 1 of that paper, which is reproduced as figure 1 of this presentation. This figure highlights the principal surface-water drainage basins in the United States. The areas of observed saline surface water are shown crosshatched. Most of the areas of saline surface waters lie in the Great Plains States and in the southwestern part of the country, notably Utah, New Mexico, Arizona, and California.

However, one note on the map at a point near the Chesapeake Bay is worth repeating: "Volume of saline water in coastal areas almost unlimited." Many of the tidal estuaries could be used as sources of saline water. For instance, the Hudson River at West Point, N. Y., may have a salinity as high as 3,000 parts per million, but the available quantity would be great. On the basis of knowledge available from small-scale plants, demineralization of this water by the ionic-membrane process could furnish hundreds of millions of gallons of potable water each day to metropolitan New York. The cost of this water on the basis of small-scale plant data might be 50 cents per 1,000 gallons. Economies of design, construction, and operation which could be proven in a large-scale demonstration plant might bring the cost down considerably, well within the range of economic reality of 10 to 40 cents per thousand gallons of treated water.

B. Ground-water supplies

Again, reference is made to water supply paper 1374. Plate 2 of that paper has been reproduced as figure 2 of this presentation. This shows the ground-water regions of the United States and the location of well fields which have been proven in quantity but which yield water of saline quality as shown by the notes in the lower right-hand corner. A casual look at this map will indicate that saline ground waters are available in most parts of the United States. Public attention may have been focused more on the prevalence of saline ground waters in the western part of the country, particularly in the Dakotas, Texas, Montana, Wyoming, Utah, New Mexico, Nevada, Arizona, and California. Some municipalities in these States are being furnished water of salinities far higher than the 1,000 parts per million regarded as the maximum acceptable by the United States Public Health Service standards. This is particularly true in areas of west Texas and eastern New Mexico. But if this country is to double its consumptive use of water in the next 20 years, many other parts of the country will have to resort to the use of this vast reserve of underground saline water and subject it to demineralization to render it suitable for public, irrigation, and industrial uses.

IV. FULL-SCALE IONIC-MEMBRANE DEMONSTRATION PLANT

A. Present installations

The twenty-odd existing installations of membrane units are treating saline waters up to the salt concentration of sea water—all on a small scale. They

have been operated by oil companies, a power utility, the Department of the Interior, the Air Force, and others. These installations have served to prove the reality of the process which in 10 years has progressed from the basic research of 2 brilliant scientists, through many development and engineering stages to a manufacturer's product which is answering the need for potable water of small groups of people in this country and abroad. The ionic-membrane unit has proven itself to be scientifically sound, reliable from the engineering standpoint, and acceptable to public-health authorities. In addition, it has shown itself to be the most economical method of obtaining potable water from saline sources, with mineral content appreciably below that of sea water.

B. Possible economics of full-scale plant construction

A full-scale demonstration plant could be built in an area such as that of Carlsbad, N. Mex. USGS paper 1374 states that well P–3 on figure 2 yields 1,400 gallons per minute of saline water containing 2,820 parts per million of dissolved solids. Many other sections of the country could be considered where wells of high yield and moderate salinity exist in areas of high water demand. Such a plant would make it possible to determine the most economical method of construction and operation of future plants. Present cost estimates must be based upon the smaller plants, which require virtually the same amount of equipment such as pumps, valves, meters, and other controls as the larger plant. Engineering experience in the construction and operation of many chemical plants has shown that cost data cannot be interpreted accurately from small-scale units to large plants because so many engineering factors are involved in the large-scale plant that can only be determined by detailed design and construction data based on an actual plant are reluctant to accept cost estimates based upon small installations. The time is near at hand when engineers will be forced to adopt the latest water-demineralization techniques in order to develop adequate water supplies for irrigation, municipal, and industrial uses. A large-scale demonstration plant constructed now would assist many engineering and water-user groups in the proper evalutation of the ionic-membrane process which most assuredly will fit into the economic picture of the future.

C. Process-control economies

Operators of waterworks of various types, as well as chemical industries, may gain some experience from small-scale units, but there is no substitute for the actual experience of operating a large-scale plant. Such an installation would permit the development of operating and control procedures to the extent that the best possible water could be produced at the least possible cost for power, maintenance, and labor. Until a large-scale plant is built and operated, accurate process-control methods and costs cannot be determined. Without these, engineers cannot be as confident as they should be in the design and construction of similar plants for other locations. The construction of a full-scale demonstration plant, as proposed in Senate Joint Resolution 135, would certainly go a long way toward satisfying engineers and water users of the reliability of operation and the reality of the cost estimates.

D. Proof to the waterworks profession

The writer is chairman of the subcommittee on water conditioning and prevention of corrosion of the water purification division of the American Water Works Association. One of his duties is to test and bring to the attention of the waterworks profession any new developments in water conditioning with ultimate installation in mind for large-scale plants. The waterworks profession must produce potable water all of the time at the lowest possible cost and with the highest degree of reliability. New processes are not accepted without convincing proof. It is not that the members of the profession are lethargic, but rather, the nature of their responsibilities makes them ultraconservative. The growing shortage of fresh water supplies will force the profession to look into newer methods of water conditioning and to seek proof of their reliability and economy.

The writer firmly believes that it will be necessary to have a plant constructed utilizing the ionic-membrane process, and to secure operating data on this for at least 2 to 5 years, before the waterworks profession will be in a position to underwrite further plants for the production of potable water for municipalities. Approvals of the United States Public Health Service and State water-control authorities must be obtained. This can most readily be accomplished by making available the data from the full-scale demonstration plant. If such a plant

were to be constructed by the Federal Government, as proposed in Senate Joint Resolution 135, it would be a tremendous service to the waterworks industry all over this country.

V. POSSIBILITIES OF A MULTIPLE-PURPOSE PLANT

The writer has been consulted by one of the large power utilities on the east coast concerning the possibility of the installation of a modern power-generating station which would also produce much-needed drinking water. Low-pressure steam could be extracted from the turbines to evaporate sea water and produce distilled water. However, excess offpeak power would be a problem in the economical operation of usch a multiple-purpose plant. This particular power company was very much interested in proceeding with an economic investigation involving utilization of the surplus offpeak electrical power for the demineralization of saline water which can be found in great quantities underground near one of their coastal installations. The ionic-membrane unit would be ideal for this purpose, but any power company would be reluctant to consider such an installation until it has been proven on a much larger scale than heretofore witnessed. In figure 3, the writer has attempted to indicate the schematic distribution of water and power in such a multiple-purpose plant.

A. Characteristics of steam powerplants

Electrical distribution systems have loads which reach a peak during the evening hours. Figure 4 indicates a hypothetical power demand curve for an electrical utility. To achieve the maximum effectiveness of the expensive power generation plant, it should operate at full capacity. This surplus power could be put to economical use in the demineralization of saline water by the ionic-membrane process. Surplus power will be available at all times with the exception of the evening hours.

B. Characteristics of efficient evaporators

Multiple-effect evaporators, whether of the long-tube, basket, or flash types, represent a large capital investment, as previously mentioned. For maximum economy they should be operated under a constant load and with steam supplied at a constant pressure. This can be done by bleeding off low-pressure steam from the turbines which drive the generators. Figures 3 and 4 indicate a steam plant where 80 percent of the steam is used for generation of power and 20 percent for evaporation of sea water. These percentages are not fixed and the design can be modified to fit the relative demands for water and power in the area being served. Such a plan would permit the steam- and electric-generating plants and the water evaporators to operate at full capacity all of the time.

C. Water production from the evaporators

Figure 3 shows that a constant rate of distilled water production is achieved from evaporator operation as specified above. The example shows 3 million gallons of water per day, but this value is not necessarily a fixed one and may be changed considerably by design. Distilled water does not taste well and must be blended with other waters in the reservoir as shown.

D. Use of excess power for ionic-membranes

Operating the generators at full capacity will permit supplying power to the communities in accordance with the natural demand, and power for the ionic-membranes in excess of the demand at any particular time. The two curves in the upper right-hand corner of figure 3 and also figure 4 indicate the division of power. For any hour of the day, the sum of the 2 usages is 10,000 kilowatts, or whatever the design capacity of the generating plant might be.

The excess power would go to the membranes for treatment of saline water which is considered too brackish for consumptive use. This might be a ground-water supply with salt concentrations ranging from 1,000 to 5,000 parts per million, or even higher. Many sources such as this can be found along the sea coasts of continental areas and islands. It would even be possible to utilize sea water, but greater economies would be achieved on brackish or saline waters.

The plant shown in figure 3 is based on the need for more power and water in many areas. Utilities envision the economies which may be achieved through multiple-purpose plants. But they are reluctant to proceed further until a full-scale ionic-membrane plant can be built and operated to prove its engineering and economic characteristics. This might well be a very effective answer to

water and power shortages in many parts of the United States where saline surface and ground waters are available in abundant quantities, and sea water is located nearby.

VI. CONCLUSIONS

1. Evidence is plentiful and irrefutable that a tremendous growth in demand for irrigation, public and industrial water supplies will take place during the next two decades.
2. This demand will force water users to tap the vast sources of saline waters in this country. The same holds true for many other parts of the world.
3. The ionic-membrane process is an economic and engineering reality on a small scale.
4. Before being widely accepted as a logical answer to the saline water usage problem by the engineering profession and water authorities, the process must be proven by a full-scale plant in the million-gallons-per-day range of capacity.
5. Senate Joint Resolution 135 is a rational proposal for proving this process and eventually making it available to solve the critical water shortages which lie ahead for this country.
6. This joint resolution attacks a problem which is desperately in need of solution, namely, how best to make available the vast saline water resources of this country.
7. The immediate present is the time when a full-scale demonstration plant of the ionic-membrane process should be constructed and operated because the answers which the plant will furnish are needed right now.
8. Public works construction programs of the next 20 years will see a doubling of water supply facilities. The need for effective means of increasing the water resources upon which public works engineers can draw is of paramount importance to the economy of this country.

Senator CASE. The next witness is Dr. Arthur Rose, president of the Applied Science Laboratories, Penn State, Pa.

We are glad to have you here and we will be pleased to receive your statement in the manner in which you wish to present it.

STATEMENT OF DR. ARTHUR ROSE, PROFESSOR OF CHEMICAL ENGINEERING AT PENN STATE, PA.

Dr. ROSE. I am inexperienced at this kind of thing. I did not prepare a written statement. All I have are some notes.

For the record I would like to state that my regular job is professor of chemical engineering at Penn State, but I also have a side job as technical director and president of Applied Science Laboratories, which is a private organization for which I consult.

I would like to put in a plea for two things, Mr. Chairman. One is that I believe that this saline water conversion is far more important than most of us think it is. I would like to explain that more fully. We all have heard many places, and again here today, about the shortage of water in this country. And I was glad to have one of the previous people who appeared indicate that this situation is becoming serious in parts of the country that are ordinarily considered as having a plentiful supply of water.

I think this needs to be emphasized. We usually think of New Mexico and California as the places that need saline water conversion. But I think in 25 years a lot of other places are going to need it. And even today we have heard that New York City is being concerned about this problem. And I know that in the State of New Jersey, chemical plants have expanded not by building larger plants in New Jersey, but by building them elsewhere in the country.

I am sure many of us think of New Jersey as a relatively well-watered State. But aside from that phase of importance to our na-

tional economy, I think there is a sort of a double international aspect to this problem.

The public and foreign relations value of a major success in saline water conversion I think might rival getting a satellite up into an orbit in its effect in other parts of the world. But then there is still another way in which a success in this area is important.

I think that our national economy needs to keep rolling in the next 25 years and that if we have water problems, this is going to delay things—industrial expansion, moving along in the way that it normally would.

We need to keep rolling here. And we cannot afford to be held back by not having water. So, I would like to point out the importance and the urgency of getting something done along these lines. And I am really happy to see these proposals for pilot plants.

Whether they be million gallons or whether they be somewhat smaller, I think often has to be decided by a careful engineering analysis of the problem. But we certainly should strive for something in the million-gallon range. And I was really happy to see Senator Anderson exclaim with vigor before he left that he wanted to build a plant.

And I think this is a spirit that we have got to have here, that we are going to lick this thing. Now, it is important as to what this means. I think it means money. I think it means larger appropriations. I think this is the real evidence. It is all right to talk about something being important, but when somebody puts money into it, this means that the money is really talking. And it is important.

So, I hope that there won't be any restrictions on that score. And I would certainly hope going back to the discussion with Secretary Aandahl that there wouldn't be any difficulties about regulations and legislation and so on. I would hope that all of the necessary requirements would be arranged.

Coming back to another point as to what actually should be done, I am going to throw something new into the discussion at this point. I think that a sizable chunk of effort and money should continue to go into research and development, because I think we have got to face the fact that the presently discussed processes may not be the answer. I am for the pilot plants because that is the only way we can get the answer. So, I think we have got to go ahead and drive on these pilot plants, but let's not count entirely on those pilot plants. I think that one can sit here and say without question that some of these proposed plants are going to be a bust.

I don't think we know whether these plants are even going to work in some cases. Now, some of them are pretty far along. Something like Badgers, that has been tried down in Harbor Island. I suppose it has been working. I haven't been down there to see it. I haven't analyzed the figures. But when you get something as big as that and it continues to work awhile, then you are pretty far along. I think by and large there are a lot of possibilities for busts here; busts in the sense of nonoperability. And, of course, another kind of failure would be that the thing would cost too much, and that the expected costs would not develop. But still we have got to go ahead with the pilot plants.

We have got to aim pretty high, as far as capacity is concerned, in order to get these questions answered.

Senator CASE. Dr. Rose, do you have any suggestions of the avenues in which this continued research should be directed?

Dr. ROSE. I think all the processes that the Saline Water Office has looked at that have been excluded by the results so far should be looked at some more. I think also that a small chunk of money should be given to people who have demonstrated interest and capability to do exploratory research, to get some really now ideas. For instance, we are restricted, I think, with all of the existing processes by getting into some kind of a transfer problem that involves a lot of surface—heat-transfer surface. And this gets you into a large capital investment. And this is where a good deal of our costs are.

Now, just maybe there is some way to get around that. Maybe you don't need to build all this expensive transfer area equipment. I don't know the answer today. But if somebody keeps working at new ways, completely new ways, to get at this problem, they will have a lot of bum ideas. But one idea leads to another. People talk to one another, and out of this could well come the real $64,000 ideas. And I don't think we have made a real breakthrough yet. We have heard this breakthrough term tossed around here. And it is rather popular these days. I don't think we have had the real breakthrough yet. We have had excellent progress compared with 5 or 6 years ago whenever it was that this program started.

I can remember the first year that hardly anybody had any ideas or interest in this saline water conversion business. I mean among technical and engineering people. Most of them felt "Shucks, this thing is hopeless and probably won't be very important anyway." They thought it was just a wild idea.

Senator CASE. Do you think the research program that has been carried on to date in the Office of Saline Water justifies the legislation, then, that was passed?

Mr. ROSE. Absolutely. I think it has gotten this thing off the ground. I think it is ready to go somewhere. That is why the pilot-plant idea is a good idea. As you have said and as Senator Anderson has said, and other people have said, the thing has gone far enough now in certain directions that you aren't going to get any real further answers here without doing the sort of thing you want to do—build a plant out there and try to run the thing. We will soon find out whether it is going to do what they say or whether it isn't.

Well, I really have nothing further to say except to repeat what I have tried to make as my main points here: that this thing is more important than we think it is. I think it is on a level above where it should be compared when it comes to working out an appropriation—I think it is on a level far above most of the other things that might compete for appropriation money. Everybody knows there is never enough money. You have to make choices. I think this thing is more important than many other things.

We in these hearings here may be making history by what we do, and the other committees of Congress that consider this program may be doing the same thing, either by positive action or by default. Let's hope it is not default. Let's hope that it is positive action and enthusiasm. This is what I would like to see, to get spirit and push in this thing and make it move along. And I think in order to do this we need these pilot plants. And we also need to have some money for research.

This does not cost very much compared with the pilot plants. You couldn't possibly spend a million dollars for exploratory research. There aren't enough people whose brains could be applied to these problems. So a little bit of money for research might really get us to the answer. That is my story, Senator Case.

Senator CASE. We appreciate the statement you have given, Dr. Rose. Thank you very much.

The next witness is Mr. Sulcer of the Graver Water Conditioning Co.

(No response.)

Senator CASE. Mr. Sulcer's statement will be made a part of the record at this point.

(The statement of Henry T. Sulcer follows:)

STATEMENT OF HENRY T. SULCER, VICE PRESIDENT AND GENERAL MANAGER, GRAVER WATER CONDITIONING CO., NEW YORK, N. Y.

As designers and manufacturers of all types of industrial and municipal water-treating equipment, we have a great interest in the saline water conversion program. Since we are best informed and primarily interested in the electrodialysis process of desalinization, we will limit our comments to that process.

We do not consider this to be a fully developed process but look on it as a very promising one. We are not sure that a large market exists for a successful device of this kind but feel that there is a sufficiently large potential market to justify our time and effort in developing a reliable and economical process. We view the field first from the standpoint of process development and process improvement, and secondly from the standpoint of market development.

Since we do not consider the membrane process to be fully developed at this time, we cannot support the provision of the resolution which would call for construction of a full-scale plant. It has been our experience in connection with other process-development projects, particularly during the war, that moving to large-scale plants too soon can not only be wasteful of money but can actually slow the development of the process. What would be a minor revision on a semiworks or pilot-scale plant becomes a major consideration on a full-size plant. We would, therefore, favor pilot or semiworks scale experimentation during the next 12 months.

In planning this work, it is of great important to differentiate between the treatment of sea water and other saline waters. The electrodialysis process looks more promising than any other process for the treatment of brackish waters containing, say, less than 5,000 parts per million of total dissolved solids. The captial investment and operating costs are proportional to the solids concentration of the water. This is illustrated in the table below which gives our best current estimates for reducing solids to 500 parts per million total dissolved solids on 3 different waters. These calculations were made according to the standard procedure recommended by the Office of Saline Water.

Estimated capital investment and operating cost to produce 500 parts per million treated water, according to standard procedure, Office of Saline Water

	Raw water solids (parts per million)		
	35,000	4,400	3,000
Capital investment (dollars per 1,000 gallons per day capacity)	3,500	500	400
Operating cost (dollars per 1,000 gallons)	4	.65	.45

We think that these figures are conservative and have good reason to believe that they can be reduced significantly by further experimentation with unit design and with improvements in the membranes.

Since the distillation processes are substantially independent of the solids in the raw water they are much more attractive on sea water and other higher solids waters at the present time. It appears to us that there is a place for more than one process because of this and other variables which exist in areas

needing desalinization equipment. All things considered, however, we believe that the electrodialysis process shows the greatest promise in the field of brackish water treatment.

Our comments on this resolution can be summarized briefly as follows:

(1) More than one demonstration plant is needed. The minimum number should be two, using the most promising method for sea water in one and the electrodialysis process for brackish water in the other.

(2) The size of these plants should be limited to pilot or semiworks scale so that improvements can be made quickly and economically.

(3) We do not feel that the Secretary of the Interior should be limited by the 6-month clause on page 2, line 5. He should be given at least 12 months.

(4) We suggest the use of the term "electrodialysis process" instead of "ionic-membrane process" to describe this method of desalinization.

Senator CASE. The next witness is Mr. Harvey Banks, director of water resources for the State of California.

(No response.)

Senator CASE. I have been informed that Mr. Banks is in Senator Kuchel's office at the present time and will appear shortly to testify.

Is there anyone who is not on the witness list who would like to make a statement?

(No response.)

Senator CASE. Mr. Jenkins, is there anything further that you wish to say for the Office of Saline Water?

Mr. JENKINS. I think not, Senator Case. It might be, however, well to correct one misunderstanding that was stated this morning. Reference was made to a publication of the Office of Saline Water in referring to a fuel or a cost of energy at 25 cents a million B. t. u.'s. And I believe that the publication which is an estimating procedure was held in some criticism because of that reason.

I would like to say just this: That publication was made as a result of the concerted efforts of a great many prominent and competent engineering organizations whose names are listed in the foreword. And a part of that estimating procedure—this is a very essential part which was clearly overlooked—is stated in the foreword. I wish to read it:

> When sufficient engineering data become available for a particular process, the estimate of costs should be refined by using actual costs, instead of percentage factors.

It goes on to say:

> All estimates prepared for the Office of Saline Water will be subject to review as necessary for comparison among processes and to accommodate special geographic factors.

That is an essential part of this procedure and should not be overlooked by anyone who is applying it. If the cost of fuel oil in southern California is more than would be represented by 25 cents a million B. t. u.'s, the manual instructs us to use that additional cost.

Senator CASE. We are glad to have your additional statement.

The next witness is Mr. Banks, director of water resources for the State of California.

The statement you have will be placed in the record as it is. The Chair would suggest that you highlight your statement in the light of the discussions which you have heard.

Mr. BANKS. Thank you, Senator.

STATEMENT OF HARVEY O. BANKS, DIRECTOR OF WATER RESOURCES FOR THE STATE OF CALIFORNIA

Mr. BANKS. I think, Senator Case, that as far as my statement is concerned, I can start out by saying that the State of California is very deeply interested in this problem of saline-water conversion. In fact, through my department at the University of California, we are actively engaged in studies of the problem to se how it fits in with our long-range plan for water development.

Senator CASE. Is there urgency about meeting the problem as far as California is concerned?

Mr. BANKS. Over the next 5 to 8 years; yes, Senator. That is, within about 5 to 8 years we will have to lay firm plans for the supply of water to southern California.

Senator CASE. What is the State of California itself doing in this field?

Mr. BANKS. The University of California at Berkeley and Los Angeles is engaged in basic research on a number of different processes. My department is doing studies and investigations in the application of those processes in various localities looking to the time when we can make recommendations to the legislature for further action if that appears necessary at the State level.

As Senator Anderson mentioned, the cost of providing for the ultimate water requirements of the State will involve an expenditure at present-day price levels of something in excess of $12 billion. It will involve the construction, in light of our present knowledge, of a very large number of reservoirs and conduits, pumping plants, and that sort of thing, to transfer the surplus waters from the northern part of the State to the water-deficient areas in the central and southern parts of the State. Obviously, if sea-water conversion should become an economically competitive process, it might obviate the necessity for some construction, particularly some of the very large conduits.

Senator CASE. Has there been any thought in California of being in a position to work in a cooperative program of research or of demonstration?

Mr. BANKS. Yes, there has. There has been an assembly interim subcommittee studying this problem for the past year, and I think I can state with safety and assurance that the legislature would be glad to cooperate with the United States in a program of further research and, at the appropriate time, construction of demonstration plants.

Senator CASE. I notice in referring to your statement that you seem to be interested in the demineralization of both sea water and brackish water.

Mr. BANKS. That is correct.

Senator CASE. Do you have resources of what might be termed "brackish water" in California that could be be developed?

Mr. BANKS. There will be, particularly in the San Joaquin Valley, considerable amounts of brackish drainage water as agricultural development proceeds in that valley. It seems to us that it will be worth while and necessary to conduct further research on the possibilities of demineralization of those brackish drainage waters for reuse. Whether the cost can be brought down, of course, to be economically competitive with other supplies we cannot tell at this particular time.

It can only be determined after further study and further research. With respect to Senate Joint Resolution 135 we are in support of it, but we do recommend that the time limit specified in that resolution in which the Secretary would have to determine the process or processes to be utilized in a demonstration plant be extended at least 1 year and possibly longer.

We feel, on the basis of our studies, that right at the present time there is not sufficient basic iformation available to the Secretary to make such a determination with finality within the 6-month period allowed.

Senator CASE. Well, if you were limited to one plant?

Mr. BANKS. I am not sure, Senator, with the possible exception of the problem in which you are particularly interested; that is, brackish water. But in the overall picture I am not sure that we could even select within 6 months either the proper process or the proper location for a demonstration plant. I think there will need to be considerably more study on that than has been done. I believe it will take at least a year; possibly less.

Senator CASE. Would it take you a year to recommend a suitable site or sites in California for a demonstration plant?

Mr. BANKS. I would hestitate to do it, or say that I could do it in less. In my opinion, the location of a demonstration plant should be selected not just to meet a particular problem but in such a way that the results obtained will be of broader application than meeting the specific problem at a specific site.

Senator CASE. Do you think there should be some correlation between the type of plant selected and the site for the plant?

Mr. BANKS. Yes. There will have to be some correlation. I would hesitate to say that we should confine our objective in a demonstration plant to solving solely the particular problem existing at the particular site. I think we should look at it in a little broader light.

Senator CASE. I think you have made your point clear.

Is there anything further?

Mr. BANKS. I believe you have my prepared statement, sir.

Senator CASE. Yes; we have your statement, and it will appear in the record.

Mr. BANKS. If there are no other questions I believe I have nothing further to add.

Senator CASE. Thank you very much.

Mr. BANKS. Thank you, Senator.

PREPARED STATEMENT OF HARVEY O. BANKS, DIRECTOR OF WATER RESOURCES FOR THE STATE OF CALIFORNIA

My name is Harvey O. Banks, I am director of water resources for the State of California. I appreciate the opportunity to present my views on Senate Joint Resolution 135, introduced by Senator Anderson. I understand that in addition to that resolution, several other resolutions and at least two bills dealing with the same subject matter are now pending before the Congress. Senator Anderson, members of this subcommittee, and the other Members of Congress concerned, are to be commended for their active interest in the possibilities of demineralization of saline water as a source of fresh water supply and for their efforts to expedite research and development in that field. California is deeply interested in this matter and offers its full support and cooperation to the Congress and to the Federal agencies concerned in carrying these studies through to a conclusion. As I will explain later, we do have some reservations as to the timing proposed in Senate Joint Resolution 135.

I would like to discuss not only the demineralization of saline water, which is the specific subject of Senate Joint Resolution 135, but also the development of nuclear energy since these two matters are definitely related. Without large amounts of cheap energy becoming available in the future from nuclear sources, it does not appear that any demineralization process now envisioned offers promise of producing fresh water from sea water in large quantities at costs economically competitive with other sources in most areas.

I would like to touch briefly on California's water problems and the studies now being undertaken by the State department of water resources of demineralization of saline water and of nuclear energy, and the possible applications thereof to the solution of those problems.

To meet present and future water needs throughout California, the State has evolved a master program of multipurpose water development known as the California water plan. Such a plan is vitally needed to assure that optimum benefits shall accrue in the control, conservation, protection, distribution, and utilization of the waters of California for all regions of the State and for all uses of water. To fully accomplish the California water plan will require much time, perhaps a century or more, the expenditure of more than $12 billion, and the combined efforts of Federal, State, and local governments and private enterprise.

A major feature of the California water plan as now developed on the basis of present knowledge and technology is the construction and operation of several hundred surface and subsurface reservoirs, as well as numerous hydropower generating, pumping, and pumped-storage plants. In addition, the plan now envisions interregional transfers of surplus waters by large physical works from regions of abundance to areas of deficiencies, often separated geographically by nearly a thousand miles and physically by intervening high mountain barriers.

Present studies indicate the ultimate water needs of the entire State of California will approximate two and one-half times the amount now required. The water resources of the State and the existing and ultimate seasonal consumptive water requirements, segregated by hydrographic area are indicated in the tabulation below. The geographic imbalance between resources and requirements is clearly evident.

Estimated water resources and present and probable ultimate seasonal consumptive water requirements

[In thousands of acre-feet per year]

Hydrographic area	Local water resources [1]	Present water requirements [2]	Ultimate water requirements	Present supplemental water requirements [3]	Ultimate supplemental water requirements [4]
North coastal	28,890	513	2,064	13	1,564
San Francisco Bay	1,245	710	3,512	42	2,257
Central coastal	2,448	630	2,246	65	1,681
South coastal	2,439	1,907	5,552	370	3,027
Sacramento River Basin	22,390	3,819	7,427	124	3,732
San Joaquin-Tulare Lake Basin (including Sacramento-San Joaquin Delta)	11,246	9,373	16,305	1,661	9,427
Operation of salinity control barrier in Sacramento-San Joaquin Delta			876		876
Lahontan	3,177	741	6,736	279	6,148
Colorado Desert	4,371	3,340	6,410		2,181
Total	76,206	21,033	51,128	2,554	30,893

[1] Including California's rights in and to the waters of the Colorado River.
[2] As of 1950.
[3] In addition to present (1950) utilization of imported water supplies.
[4] In addition to California's rights in and to the waters of the Colorado River.

Whether all of the very large interregional transfers of water now envisioned as necessary in the future to supply California's increasing needs for water will finally be constructed or whether the demineralization of brackish and sea water will provide some of the future requirements, is as yet a matter of conjecture. If competitive demineralization processes are developed, the locale of application will largely be dictated by economics. Obviously, large savings may be possible.

The California State Legislature fully realizes the probable implications to

the State's interests of developments in the field of water demineralization and in the application of nuclear energy to solution of water problems, as does the department of water resources. During the past year, a legislative interim committee has been actively studying these matters.

It is anticipated that the legislature will appropriate approximately $104,000 to the department of water resources for fiscal year 1958–59 for investigations in the fields of demineralization and nuclear energy, with the directive that these studies be expedited as much as possible. The legislature has similarly requested the University of California to speed up and expand its basic research programs.

To accomplish this expanded program, the California Department of Water Resouces is now organizing a specialized, highly technical engineering section to investigate not only all phases of the sea- and brackish-water conversion problem, but also to study the possible uses of nuclear energy as sources of heat or electrical energy for demineralization processes and as sources of electrical or mechanical energy for pumping; several specialists have already been recruited. The latter studies will include full consideration of the possibilities of the generation of hydroelectric energy for peaking purposes through the use of pumped storage using offpeak energy from nuclear reactors and/or other sources for pumping. Should definite profitable avenues for further investigation and development be revealed, the department will, subject to the availability of funds, take full advantage of possible cooperative arrangements with Federal and other public agencies and of the employment of private organizations to continue detailed investigational and developmental work. A considerable number of private companies have been contacted and are ready to assist the department when it appears advantageous to actively pursue definite developmental phases.

With regard to the need of large-scale water demineralization plants and the applications of nuclear energy in California's water development program, it is believed that at least 5 years are yet available before definite decisions must be made regarding possible major applications. Thus we have ample time to conduct the basic research and pilot-plant studies which are still necessary to obtain conclusive information as to processes, materials, design data, and costs.

The most immediate need for large amounts of supplemental fresh water in California is for irrigation in the San Joaquin Valley. There is no prospect whatsoever that this need could be met by demineralization of sea water at costs even approaching those involved in conserving and importing fresh water from streams of the Sacramento Valley such as the Feather River. However, the demineralization of brackish drainage water may offer some promise in the future.

The immediate efforts of the department of water resources in the field of water demineralization are directed toward (1) the collection of all available research data, design, operation, and maintenance data for existing and planned saline-water conversion units in the United States and abroad, (2) putting these data on common bases to enable comparative analyses, and (3) evaluation to determine the most promising processes, possibilities of new processes, and cost and design data. We are working closely with the Office of Saline Water, United States Department of the Interior, in the scientific and technical phases of the water-demineralization program. Close cooperation is being maintained with the research work of the University of California at Berkeley and at Los Angeles in the fields of saline-water conversion processes and low-temperature nuclear reactor development.

It is also contemplated that arrangements may be made for supplementary studies by such organizations as Scripps Institute of Oceanography, Stanford University, Stanford Research Institute, California Institute of Technology, Massachusetts Institute of Technology, and the University of Wisconsin.

Prepilot-plant investigations will soon be initiated for several locations in California, including use of processes suitable for the demineralization of brackish drainage water in the central San Joaquin Valley, reclamation of sewage, and the possibilities of sea-water conversion units in the vicinity of Monterey, the San Luis Obispo-Santa Barbara region, Los Angeles, Avalon, and at San Diego. These sea-water conversion unit studies will consider the use of waste industrial heat sources and the use of the thermal potential of sea water in coastal submarine basins and canyons, perhaps supplemented by solar heating of surface waters and/or by secondary electrical or heat energy.

Other sources of energy, whether for eventual large-scale or for small-scale uses of electrical, mechanical, or thermal energy or for water demineralization, are being encompassed in the studies of the department of water resources.

23642—58——14

These investigations will include the use of wind, tide, ocean waves, thermal potential of sea water, solar energy, heat pumps, waste, and secondary utility and industrial electrical and heat energy, etc.

Our studies to date indicate that no demineralization process for the conversion of sea water in its present stage of development appears to be competitive in most areas of California with water from natural sources. It is our opinion that to be useful to consumers of domestic, municipal, and industrial water in California, the total cost must show promise of ultimately approaching $80 per acre-foot. This figure is very nearly that of the cost of fuel or of energy alone in the majority of the more economical conversion processes developed to this date. Further research and development will no doubt lower the costs substantially below those which now appear possible.

Therefore, it is believed that at this time, we do not have the fundamental knowledge required to select the best process nor the design data necessary for the construction of a large sea-water-desalting plant. Rather, there is need for more basic research closely coordinated with careful and detailed engineering analysis so as to obtain reliable operational and cost data for those processes that appear to offer promise of solutions to the problems of demineralization. Such studies should be expedited as much as possible.

A number of small desalting plants are now in operation in several parts of the world where there are no other possible sources of fresh water. It is suggested that teams of technical experts be sent to observe the functioning of these plants so as to obtain accurate operational and cost data. In a like manner, reliable information should be procured from the designer and constructors of these units regarding total capital costs. On the basis of such fundamental information, more effective avenues of research and related developmental requirements can be evolved.

As noted above, large areas of California have water requirements both present and future, far in excess of their local water resources. These include the San Francisco Bay area, central coastal area, southern California, San Joaquin Valley, the Lahontan region, and the desert areas. At the present time, our most urgent water problems are those of the interior valleys. Demineralization of sea water may well assist in the future alleviation of the water shortage problems of the coastal areas. In the interior areas, as previously noted, demineralization of brackish drainage waters appears worthy of future study. Therefore, we believe that further research, experimentation, and finally operation of large-size pilot or demonstration plants for the desalting of both sea water and brackish water should be conducted as expeditiously as possible. The most feasible process may not be the same in each case.

With respect to the location(s) of a demonstration plant or plants, it is believed that California, because of the wide variety of our water problems and the urgency thereof, should be selected. In the news release concerning this hearing, mention is made of the possibility of cooperation with State and local agencies. I want to assure you that California will be more than willing to cooperate to the fullest possible extent in the design, construction, and operation of a demonstration plant at the appropriate time, either for demineralization of sea water or brackish water or both.

The following points are suggested for your consideration:

(1) Since, as yet, no definite water demineralization process has shown itself to be economically competitive with natural sources of supply, the construction of a demonstration plant should not be undertaken for a year or two until a thorough, detailed appraisal of present processes and existing plants is obtained and possible more profitable avenues of research are determined and evaluated.

(2) More factual information should be obtained and prepilot plant engineering studies should be conducted so as to procure sound bases for the selection of possible economically justified methods and of plant locations.

(3) When the investigations result in the selection of a process, or processes, which appear to offer solutions to the problem of economical water demineralization at specific locations, then demonstration plants should be constructed and operated to obtain full and accurate design and cost data.

(4) Such studies should encompass the demineralization of both sea-water and brackish water.

We urge the passage by Congress of Senate Joint Resolution 135 to expedite the research program on demineralization of saline water and to provide for construction of demonstration plants but we recommend that the Secretary of Interior be allowed more than the 6-month period now specified in Senate Joint

Resolution 135 in which to select the process to be used. At least 1 year, and possibly longer, will be required to conduct the necessary research and studies to properly select the processes and determine the proper locations for demonstration plants. To shortcut these essential first steps might well result in costly failure.

Once the decision has been made to construct a demonstration plant, we strongly recommend that it be located in California. The State of California is willing and anxious to cooperate in every way possible in the solution of this problem.

The Congress of the United States is to be commended for its foresight as to the possible implications of the development of economical water demineralization to many areas of the country.

Mr. LINEWEAVER. Mr. Larrecq would like to make a short additional comment.

Mr. LARRECQ. Mr. Jenkins was kind enough to explain the circumstances by which a price of 25 cents per million B. t. u. was arrived at. But that explanation does not alter the precise question that was raised here this morning, Mr. Chairman, as to whether the estimate of cost of product, dollars per thousand gallons, which were stated in the hearing are based upon the precise figure given in the report or based upon some other.

And I do believe, Mr. Chairman, that the question is very pertinent.

Senator CASE. You will recall that the Chair suggested at the time that the committee staff analyze the statements presented with respect to costs to determine whether or not that fuel factor was on the basis of the suggestion in the booklet or on the basis of actual cost.

Mr. LARRECQ. Yes.

(Senator Anderson subsequently ordered the following communications inserted in the record:)

LETTER FROM D. OTIS BEASLEY, ADMINISTRATIVE ASSISTANT, SECRETARY OF THE INTERIOR

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D. C., April 1, 1958.

Hon. CLINTON P. ANDERSON,
Chairman, Subcommittee on Irrigation and Reclamation,
United States Senate, Washington, D. C.

DEAR SENATOR ANDERSON: As requested by Senator Case for information to be used by the committee in executive session concerning the various costs presented at the recent hearing on Senate Joint Resolution 135 by the various witnesses, the following is submitted.

Before it is possible to determine definitely whether or not an organization has utilized all of the Office of Saline Water "Standardized Procedure for Estimating the Costs of Saline Water Conversion," it is necessary to have computations before us concerning the various assumptions and costs that they present. We can say that Fluor Corp. did present costs that were compiled in accordance with the standard procedure and with projected cost of theoretical nuclear steam plants. In addition, it is our understanding that Westinghouse, Griscom-Russell, Maxim-Silencer, and Ionic feel that they have applied the Office of Saline Water cost estimating procedure to their various processes. The figures given at the hearings by Mr. Badger were made before the standard procedure was prepared, and when the data were recomputed by the Office of Saline Water in accordance with the standard procedure, the 30-cent figure came out to about 40 cents.

It should be noted that the figures given by Griscom-Russell and Maxim Co., are for combination power-water plants. We are unable to confirm whether or not power generators utilized the standard procedure.

Should you have further questions, we would be pleased to answer them.

Sincerely yours,

D. OTIS BEASLEY,
Administrative Assistant, Secretary of the Interior.

LETTER FROM DR. EVERETT D. HOWE OF THE UNIVERSITY OF CALIFORNIA, AT BERKELEY ON DEMONSTRATION PLANTS

UNIVERSITY OF CALIFORNIA, *April 10, 1958.*

Senator CLINTON P. ANDERSON,
Senate Office Building, Washington, D. C.

DEAR SENATOR ANDERSON: You may recall our brief discussion when I visited Washington on March 25, at which time I promised to send you some comments regarding the desirability of constructing demonstration plants for the demineralization of saline waters, as provided in pending Senate bills.

While there is need for considerably more fundamental research and small-scale pilot-plant exploration on many of the schemes proposed for demineralization of water, there are some schemes which are sufficiently far developed that demonstration plants could be built in the near future. The construction of such plants may serve the purpose of stimulating the research and small-scale work on the less well developed methods and hence would be quite desirable. Several facets should be given consideration in the development of any demonstration-plant program.

The primary consideration should be that new methods will be given emphasis. It is my feeling that manufacturers of conventional equipment have made very substantial improvements in the economy and capacity of their equipments over the past several years, this being exemplified by the new plants at Aruba and Kuwait. It is probable that these manufacturers and engineers will continue to improve their plants through the normal stimuli provided by competition. Thus, it would seem to me that demonstration plants, if constructed, should emphasize the methods not yet applied commercially.

It would seem desirable to construct a number of demonstration plants, rather than to spend the entire sum on 1 or 2 plants. I make this comment because the size of the demonstration plant essential to display the characteristics of the equipment need be equal only to the maximum size in which the given equipment can be constructed. For example, the new distillation plant at Aruba consists of four identical trains of heat exchanger, each of which has a capacity of one-fourth that of the plant. Thus, a demonstration plant using this equipment need not be more than the equivalent of one of the trains of heat exchangers. I believe this same comment is true of most of the other developments.

No doubt it would be desirable to have some of the plants constructed for demineralizing saline water, and others to demonstrate the demineralization of sea water, since the methods appropriate for solving these two problems differ.

The locations of the plants should probably be in areas where the water supply could be usefully employed and is needed. For saline water, there are areas in the Dakotas, in Texas, and in Arizona, where such installations probably would be welcomed. For sea water demineralization, the two areas which are most critical at this point are southern California and the Virgin Islands. I suspect that both of these locations would welcome installations of water plants.

One of the principal objectives of any demonstration-plant program should be that of obtaining performance data on full-scale plants in an accurate and comprehensive manner. I believe that data acquired for this purpose would have considerable significance in accomplishing the transition from laboratory work to full-scale plant design. For example, if the demonstration plant were to be designed and installed with instrumentation sufficient for obtaining performance data, there should be possibly a period of operation under controlled conditions so that some agency, such as the OSW, would be able to obtain data on costs and performance of the various components as well as of the entire plant. These tests would be possible only if plans are made in advance of the plant construction. There will be required instruments and measuring facilities not normally used in the operation of a production plant. While this is a detail which no doubt would be best considered by the agency responsible for the demonstration plants, I think it should be kept in mind as one of the many facets of any demonstration-plant program.

It is my general feeling that, under the conditions noted above, a demonstration-plant program at the present time might be quite helpful in stimulating the basic research program and in bringing to the attention of many people the nature and magnitude of the problem which has been tackled on such a modest scale under the auspices of the OSW.

I hope the above remarks will be helpful to you at this time.

Sincerely yours,

EVERETT D. HOWE,
Professor, Mechanical Engineering.

Mr. LINEWEAVER. Senator Case, we have received several communications that we would like to have printed in the record at this time. They are as follows: a statement from Dr. Kalman Held, of Technical Research Corp., New York City; a letter containing a description of the Reams process for the desalination of sea water from E. Walter Scott, of Reams & Scott Explorations, Washington, D. C.; a letter from Early W. Moore, of Chowchilla, Calif.; and a letter from Bryn Beorse. The latter two letters were presented for insertion by Senator Anderson.

We also have a letter from Dr. Richard Harvill, president of the University of Arizona, addressed to Senator Hayden, chairman of the Senate Appropriations Committee, enclosing a statement by Dr. Sol D. Resnick, hydrologist with the University of Arizona, on the proposed United States Government plant for demineralization of brackish water.

Senator CASE. Without objection, they will be printed in the record.

(The communications are as follows:)

STATEMENT OF DR. KALMAN HELD, TRG, INC. (FORMERLY TECHNICAL RESEARCH GROUP)

I am pleased to accept your invitation to submit my comments on Senate Joint Resolution 135 and the accompanying news release. My professional experience includes a doctorate in physical chemistry and 17 years of research in the fields of saline-water conversion, nuclear energy, and materials research. I am vice president of TRG, Inc., a small but rapidly growing company whose basic activity is sponsored research and development. TRG's areas of activity include nuclear reactors and shielding, electronics devices and components, basic physical chemical research including studies on saline-water conversion.

For the past several years I have been concerned with the technical and economic problems encountered in converting sea and brackish waters to fresh water. This has included experimental and theoretical studies as well as a comparative survey of various methods for desalinizing water.

With regard to Senate Joint Resolution 135 and the accompanying news release it is my belief that the appropriation of $10 million for construction of saline-water conversion facilities is well merited. However, at this time it would seem more desirable to use the funds for the construction and operation of two or more pilot plants. Allocation of funds for construction and operation of a pilot plant for demineralizing brackish waters should certainly be a part of the program. This is due to the fact that there are many areas of the country where brackish waters are present. Under certain conditions the cost of demineralizing brackish waters may reach a low level. In addition one or more pilot plants using a sea water feed should be constructed. These plants should have a capacity of about 1 million gallons of fresh-water production per day.

It ought to be recognized, however, that in the light of the current water economy and the state of the water-conversion technology, no system will at this time be capable of demineralizing water at low enough cost for broad general use. The primary purpose of the construction should therefore be to advance the technology through the experience gained in the construction and operation of plants of a sufficiently large size to be of engineering rather than of laboratory interest.

Such an enterprise must necessarily be undertaken with Federal aid. It is to be hoped that the Federal aid will be offered in such manner as to invite increasing participation by private enterprise and to respect the rights of local governments in policing water supply.

While we most heartily concur that constructions of operating systems to examine further those methods now most promising are timely and would greatly benefit the technology, we believe that a well-rounded program should give attention to other aspects of development. In particular, we believe that the current program should include the following:

1. Construction of several pilot plants embodying systems at present most attractive.

2. Further support at the laboratory level for systems which hold a large measure of promise for the future.

3. Further support of studies to explore new avenues to the solution of various problems; i. e., generation of fresh ideas.

4. Construction of a small laboratory dedicated to the purposes of water conversion.

This program, we feel, would lead to a rapidly developing water technology at relatively small cost; for research in water demineralization is much less costly than many other prominent fields of research funded by the Government. For example, we believe the above program would be adequately funded with approximately $10 million for item 1, $2 million for items 2 and 3, and $3 million for item 4.

Items 2 and 3 are largely self-explanatory. It is desirable in their execution to bring the fullest amount of talent to bear, private enterprise, large and small, universities, and Government laboratories. Item 4 is new to the saline-water program. The proposed laboratory could be modeled administratively after the AEC national laboratories—on a much more modest scale. The laboratory would centralize equipment and facilities necessary to investigate any part of the program. Its location ideally would be coastal in a warm climate. It would be versatile enough to perform any support work that could not conveniently be done elsewhere. Such a center might later become a focal point for solar energy and for oceanographic studies.

EVALUATION OF SALINE WATER CONVERSION METHODS

The following methods may be considered in a sufficiently advanced state of development to warrant consideration for construction of pilot plants at the present time:

Multiple effect evaporation
Compression distillation
Ion permeable membrane method

A number of other methods exist for which some bench data is available but which are not at a stage to warrant relatively costly capital investment. However, these may be ultimately less costly than the above. It is suggested very strongly that research and development continue in these fields. This will be considered in more detail in a later section.

A third class consists of those pioneering methods for which process feasibility has not been established. These warrant a modest amount of funding for continued research.

The most important feature of the program for long-term benefits is research intended to improve the state of the art. Research programs should be carried on to improve existing systems and to develop new ones. The importance of relatively modest investment in fresh ideas cannot be overestimated. Out of them will rise the great projects and the technology of the future.

The research program should not only look to the future but should also address itself to immediate problems. In this manner a strong current technology will be developed and maintained in support of operating projects.

It is specifically recommended that the following topics be investigated (in connection with items 2 and 3 above):

1. (*a*) Conduct research on methods to increase overall heat transfer coefficients.

(*b*) Conduct research on methods to prevent or control scale deposition.

(*c*) Prepare new permselective membranes and measure their properties.

(*d*) Continue engineering studies on various solar stills.

(*e*) Conduct preliminary engineering and economic studies of a multipurpose plant for the production of desalinsed water, electrical power, brine, and related chemical products.

(*f*) Conduct engineering studies on various distillation methods.

(*g*) Investigate the potential of nuclear reactors as energy sources.

2. To support research at a modest level on selected seed ideas which are expected to contribute to the state of the art.

We cannot conclude without emphasizing the desirability of pursuing and developing this technology. Nature's resources of fresh water are limited. Parts of this country already suffer from inadequate supply. The pressure of increasing population and increasing per capita demand for fresh water will inevitably and in the not-distant future expand the size and number of our water poor regions. Many foreign nations in whose welfare our country is

deeply interested face immediate, and sometimes desperate, need for more fresh water.

Fresh water is primarily a material of peace and prosperity. The rewards which accompany its abundance is great. The cost of advancing the technology of water purification is relatively small.

LETTERS FROM REAMS & SCOTT

REAMS & SCOTT,
Washington, D. C.

Hon. CLINTON P. ANDERSON,
Chairman, Subcommittee on Irrigation and Reclamation,
United States Senate, Washington, D. C.

DEAR SENATOR ANDERSON: Your Mr. Langweaver has instructed us to submit the pertinent facts relative to the Reams process for the desalination of sea water (saline water) to you as the chairman of the committee now considering the process, or processes, best suited for immediate construction and test, under the direction of the Secretary of the Interior.

As sponsor to the presentation of this new process to your committee, it gives me a great deal of pleasure to recommend it, for I have witnessed the operation of the primary Vaptor unit Mr. Reams invented from the beginning of the experiments. He has labored tirelessly with fortitude and diligence to overcome many problems. It is operative and does all that he claims and may, if given the chance, be the answer to the vexing problem of water supply now affecting our national economy.

I trust that you can give this process your consideration at the moment and that the inventor will be rewarded for his lone effort, also that recommendation to the Secretary of the Interior and the Assistant Secretary, Hon. Fred Aandahl, will be to thoroughly investigate the Reams process and its possibilities.

I want to thank you at this time for hearing the prior short description of the Reams process at a dinner gathering recently where I had the pleasure of meeting you.

Sincerely yours,

E. WALTER SCOTT,
Partner, Reams & Scott, Explorations.

THE REAMS PROCESS OF DESALINATION OF SEA WATER

It is gratifying to learn that the remarks made by Senator Anderson in the United States Senate on January 9 have borne fruit in the passage of a joint resolution (S. J. Res. 135) to provide "for the construction by Department of the Interior of a full-scale demonstration plant for production from sea or other saline waters, of water suitable for agricultural, industrial, municipal, and other beneficial consumptive uses * * * 1 of 3 most promising saline water conversion processes currently under study in the Department of the Interior."

Because of current experiments and the patent situation (disclosure limitation), the Research Operations, Inc., under whose auspices the research effort has been pursued, has not been able up to now to enter into any arrangement with the Secretary of Interior after a preliminary contact with his office (January 1956) relative to a joint venture agreement. Improvements have been made on the Vaptor and still of the Reams process since the first contact.

The experiments in the laboratory on the Reams process have been successful using a 1,200 to 1,300 gallons unit operated from 4 minutes down to 1¾ minutes intermittently. The optimum result has been gained at the aforesaid minimum period of time, a 78 to 83 percent reduction in salinity in only 1 pass through the Vaptor. Higher efficiency can be had with minor design refinements.

To produce 1 million gallons of potable water in 1 day, it is proposed to provide 80 Vaptor units through which the raw water would be passed after removal of algae and bacteria and a process clarification, then to the secondary still followed by purification of water free from any deleterious substance in a self-flushing Dialyzer of the inventor's design as interposed in the system. After this process pass, correction of pH could be made before all water is passed through a filter bed prior to storage and feeding into the distribution system.

This Reams process further provides valuable brines 120,000 to 160,000 gallons from each million gallons processed. This credit can more than outweigh the

plant cost and process cost of the water treated. A rough estimate of 0.04 per gallon at plant site would yield $4,800 revenue per day. These brines can be reduced in Hooker cells of a chemical plant or used directly in treating titanium metal in reduction from its ores (Reams process) or in processing of petroleum products. This would be particularly applicable to Texas coastal area (from Corpus Christi to Port Arthur) or California (Los Angeles).

At 40 cents per 1,000 gallons cost for the Reams process a million gallons of processed water would cost $400, less revenue of the credit item is 4,400 per day earned. The inventor is frank to admit other water processes do not provide a byproduct of value in the current industrial processes. There is no scale to contend with in processing water as in other processes, there are no membranes, just alloy wire, piping, and not-so-complicated equipment that can ultimately be automated readily. This should reduce by half the maintenance staff normally required to 3 persons under a supervisor.

An estimate to provide a saline water plant to reduce to potable water supply for the city of Aransas Pass, Tex., was submitted in 1956 to provide 1 million gallons of water. At the time, the site was to be provided (22A), and the plant facilities and equipment was estimated to cost:

With steel tanks 28 feet in diameter capable of storing the day's production [1]	$978,000
With wooden tanks 28 feet in diameter capable of storing the day's production	820,000

[1] Fresh water and brine product.

The byproduct brines were to be disposed of at nearby refineries or chemical plants.

An 8-percent increase of material and labor cost over the 1956 estimate would give:

With steel tanks	$1,056,240
With wood tanks	885,600

Another specific instance that might be cited is a suggested scheme of using the Vaptor to remove salinity from river water used by the city of Dallas, the river contamination being due to dumping of raw brine pumped from oil wells.

Another instance is the growing need of water for chemical plants needs being for more than double the present 9,700,000,000 gallons need by 1975 (Chemical Week, June 29, 1957). Present requirements and water lack dictate locating all plants away from industrial saturated areas with resulting lack of skilled labor in that particular area. Dependence upon ground water is hazardous for the levels rise and fall with wet and dry years. "State governments are taking steps to alleviate shortages—diverting rivers, building huge aqueduct networks, pipelines, erecting dams, and appropriating huge sums for treatment plants" (p. 23, Chemical Week, June 29, 1957). When one considers the practicality of these moves, the source water and the time and expense for availability and final utilization must be weighed against the final result. Economically, when the Reams process is considered, 9 months is the maximum time weighed against several years minima to provide these foregoing natural facilities. With 90 percent of the chemical plants being built in Texas, time will not allow resorting to natural or ground water supply there to fill the need. Six 1-million-gallon plants of the Reams process could be used now in the Texas coastal area. For this reason, action on the bill proposed by Senator Case (S. 3370) to provide several plants is a must. In the writer's opinion, Mr. H. D. Banks, director of Department of Water Resources, State of California, stated some startling facts at the Senate hearings relative to needs of his State. Also, Indiana, Ohio, and Oklahoma are inland States where the water pinch is now felt. Since the Reams process is primarily for sea water desalination, use in the States of California, Rhode Island, New Jersey, and Texas would alleviate the water shortage.

Manufacturing facilities for the Vaptor and other units are being currently arranged so that the Reams process can be marketed. The process is one of the few with which Permutit compounds can be utilized readily and efficiently with utmost economy along with other pieces of standard equipment.

The basic phenomena upon which the Reams Vaptor, primary unit in the process, is based, falls within the basic concept first expressed by Planck and Bohr; later by Goudsmit—having to do with electron behavior on its axis of symmetry. Later substantiation of the "H" nuclear moment was set forth by O. Stern, projected through a strong magnetic field having angular gradient.

Support of this can be based on Albert Einstein's findings in "principle of inertia of energy," including the electromagnet, manifests the same inertia characteristics as material bodies; possesses mass "m." Then, for a "radiating energy 'E' the value is calculated from the universal : $E=mc^2$, as $m=E/c^2$." [1]

One may assume further, based upon the concept by Dr. Jakob Mandeleker: "Dependence of the body on its energy content is incompatible with classical assumption of constant mass; i. e., independent of velocity." [1] Herein is mass variability. Assuming this and known principles, magnetic effect of a current, in ergs, indicates the inventor has here applied to his process "mmf" to perform the work of separating substances in solution (anions and cations) in presence of magnetic forces.

Upon the first explanation of his basic device to Assistant Director of Office of Saline Water (1955), an adverse report was given The device has since accomplished in a laboratory what the inventor anticipated it would do. Here is a new primary process differing in basic concept from all others, understood only by those having knowledge of the highest physical sciences.

The chairman and members of the subcommittee are welcome to visit the laboratory in the near future if there is interest in the Reams process. We thank the committee and members of Congress for the opportunity of presenting these facts at this time.

WASHINGTON, D. C., *May 5, 1955.*

Hon. JOHN J. BELL,
Member of Congress,
142 House Office Building, Washington, D. C.

DEAR CONGRESSMAN BELL: I have very thoroughly checked the saline water conversion program and the third annual report, January 1955, of the Secretary of Interior. There has been a serious and concerted effort to promote many of the known processes and to test them. For the treatment of saline waters in large quantities, some of the ones being tested may never prove economical. A phase not mentioned that must be carefully weighed is that certain existing patents are applicable principally to the testing of waters for saliniy and potability. However, the licensing of such might not prove to be practical. An evaluation of the methods being tested might be made so that relief can be provided for distress areas now in dire need of water.

The processes being tested that may prove applicable to the Texas areas are: one being checked at the University of California to use molecular oil films for large-scale low-cost sea water demineralization. The Texas A. & M. has the most practical on test. Some study might be directed toward the utilization of the waxes produced by Texas refineries, in their present direct approach. Other methods on test showing promise are large dializers.

The preliminary patent drawings of my process have been submitted to the Chief of Division 48 (U. S. Patent Office) and there is no interference to his knowledge. It uses low-voltage current, magnetism, and a new concept in utilizing some of the graphitic and refinery products is incorporated into the whole. However, I am doing no shouting from the rooftops until it is tested: There are several laboratories in this area equipped to do the work. I am presently checking into the matter.

The Southern Pacific Railroad is providing maps and site locations for the proposed plant near Aransas Pass and Reynolds Metals have the waste tailings disposal from LaQuinta across from Corpus Christi still up for decision. There was a slight misunderstanding as to information that temporarily held up their decision, which I may expect in the very near future. They are disposing of this at present by dumping waste material out in the Gulf of Mexico, so I am advised.

Your assistance in this matter is valued and much appreciated.

Sincerely yours,

CLINTON AUGUST REAMS,
Consulting Engineer.

---

[1] Matter Energy Mechanics, p. 2, Mandeleker, Philosophical Library.

LETTER FROM EARLY W. MOORE

CHOWCHILLA, CALIF., *March 20, 1958.*

Hon. CLINTON B. ANDERSON,
Senator from New Mexico,
Washington, D. C.

DEAR MR. ANDERSON: Due to illness, I was prevented from accepting an invitation by Congress to state my views on desalting sea water.

I am still of the opinion that the possibilities of windmills are being neglected. One prime consideration is, they use no fuel.

New type windmills are now in production which will produce 100,000 kilowatts each. California has a few very fine locations for such. One is in Imperial Valley and another the Mojave Desert.

Imperial Valley being below sea level would lend itself to the evaporation of sea water or the Salton Sea. Electricity could be transported to the San Diego area to be used for evaporating sea water to relieve that area's shortage. Windmills in the dustbowl could prevent the tragic conditions of the past.

The Mojave Desert could be used to send electricity to the ocean where it could be used to desalt sea water to be used in that vacinity, or it could be used to separate sea water into hydrogen and oxygen. Hydrogen being a very light gas would flow back to the Mojave Desert where it could be burned, producing at the same time the same amount of energy as was used to separate it. This energy would be in the form of superheated stream which in turn could be used to turn turbines to generate more electricity to separate more water, producing more hydrogen to produce more stream to turn more turbines. This method should be cheap enough for homes anywhere on the desert.

This is very brief. To carry this out would require a corporation, Government participation, and sponsors.

The cost of a pilot plant would be small compared to that of some of the proposals.

Hope your bill can include an appropriation for a committee to complete data on such project.

Yours sincerely,

EARLY W. MOORE.

LETTER FROM P. M. SLOANE

OLYMPIC HOTEL,
Los Angeles, Calif., April 4, 1958.

Mr. GOODRICH LINEWEAVER,
Senate Interior Affairs Committee,
Washington, D. C.

DEAR MR. LINEWEAVER: I just received a letter from my attorney in Washington, D. C., Mr. Jacob N. Wasserman, who is taking care of another matter advising me to send to you and your committee the information of a sea water project I am connected with that eminates abroad.

Enclosed is a clipping that briefly explains this process.

The inventor who developed this marvelous process has received worldwide publicity regarding another patent along this field in 1956. His name is Alexander Zarchin. Resides in Tel-Aviv, Israel.

I flew there last August to bring back with me what he had newly developed. This has now been patented recently; January 28, 1958, to be exact. He claims that he can, in volume production, bring the cost of sea water down to as low as 10 cents per 1,000 gallons.

What we are aiming to do right now is construct a pilot plant to cost no more than $300,000 to prove this process. I have been in touch with top sea water scientists in the West and they all concede to the fact that his patent is very novel and offers tremendous potential of what he claims. But to prove his claims we must first build the pilot plant because nothing has ever before been proposed with the novel claims the patent office has granted him. Because of its unusual features in claims, they were able to bypass the usual time it takes to issue a patent and grant him his in less than 1½ years.

I would like this letter to be on record to request the possibility of receiving this $300,00 from the Government for this project.

Could you reply stating what would be the procedure to follow through from this point on?

Please reply at your earliest opportunity as I may decide to come East shortly and your answer will help me very much to shape up my program. Thanking you,

Yours truly,

P. M. SLOANE.

SLOANE PRESENTS ISRAELI'S SEA WATER CONVERSION PLAN TO CALIFORNIA CITY

A communication from Alexander Zarchin, Israeli scientist, whose method of converting sea water to fresh is being introduced in the United States, reveals that the pilot plant being constructed in Israel will be ready in 2 months. This was made public by "Peppy" M. Sloane, the American representative for the Zarchin Inventions Exploitations Co., Ltd., of Tel Aviv.

Mr. Sloane, who has been presenting the scientist's plans to California communities, recently addressed a meeting at city hall, Imperial Beach. The session to consider the conversion process was attended by Mayor Cecil H. Gunthorp, City Manager Al M. Carnesciali, Col. L. W. Maly, USA retired, and Mandley P. Sturdy, general manager of the Imperial Beach News.

Mr. Sloane described the Zarchin process as one of freezing, using standard equipment that is fully automatic and provides for no byproducts, the residue being returned to the ocean.

The smallest pilot plant which could be enlarged by the addition of more units would cost $285,000 according to "Peppy" Sloane. This would produce approximately 250 million gallons of water per year at a cost of 50 cents per thousand gallons. This compares with water now being delivered locally to customers at the rate of 44 cents per thousand gallons, it was pointed out.

Mr. Sloane stressed that equipment for the process could be built up to such an extent that water could be provided at a cost of about 10 cents per thousand gallons.

Further meetings following study of the plants and consideration by the city council of Imperial Beach were indicated.

MARCH 8, 1958.

LETTER FROM BRYN BEORSE

Senator CLINTON P. ANDERSON,
U. S. Senate, Washington, D. C.

DEAR SENATOR ANDERSON: You may recall our correspondence a couple of years ago about your atomic energy sea water conversion interest which I though should be brought to the attention of the unique committee on sea water conversion at the University of California. This committee is unique in the sense that it is established and draws its personnel from the first University or institution of any kind in this country that took up a serious study of sea water conversion, backed by practical tests. Especially the committee's chairman, prof. Everett D. Howe, the outstanding expert on sea water onversion in this country and Dr. Edward Teller, the committee's nuclear science consultant, would have benefited from acquaintance with your project and would in turn have benefited it.

In 1949, when I returned from France with information on the thermal difference system of sea water conversion which the French had worked on for decades, I believe I was in touch with most people in this country interested in the general problem both in Washington, D. C., and at scientific and industrial research bodies throughout the Nation. The National Bureau of Standards in Washington, D. C., built, on my instigation, two small thermal difference plants which I understand were instrumental in making Congressmen vote into existence the Saline Water Office of the Interior Department, which Office has done fine work and the best it could with its limited means and personnel, but of course never could command the broad scientific knowledge of the large University of California, which has kept its lead in the field of sea water conversion.

It greatly pleased me to hear of your Senate hearing on the subject of $10 million to be granted for demonstration plants for sea water conversion. I trust that this will be a broad and useful hearing that may bring about a thorough sharing of scientific data so the taxpayers' money in this matter will be efficiently utilized. Despite scattered efforts there has been no such complete sharing of information so far. As a minimum such a hearing would have to

include Prof. Everett Howe of the University of California; Dr. Edward Teller; Dr. Columbus Iselin of Woods Hole, Mass., our greatest authority on the oceans, employed by all armed service branches on structures in the ocean and besides, a keen observer of the various approaches to sea water conversion—and of course myself, whose benefits to such a hearing I can hardly count.

The thermal difference system, I believe, was the first to be offered as a basis of a large conversion plant in the plan so far sketch offered by the University of California. The cost of water from such a plant would be less, much less, than any suggested by any other scheme so far offered and based on sound estimates. But this in no way singles out the thermal difference system as the best or only approach. Rather what should be sought at the hearing is a combination of present promising approaches to produce the best possible synthetic result. With this in view the University of California approached the Atomic Energy Commission as early as 1952 and has had a good deal of correspondence with the Commission about a combination of atomic energy with one or more of the new approaches to the specific problem of sea water conversion. Without such a combination of thorough knowledge of the sea water conversion approach combined with a knowledge of nuclear techniques a satisfactory solution cannot be found. It is not sufficient to have consultants in this matter who have a good name in some branches of science. Such persons can make serious and tragic mistakes as evidenced in articles and a book written on sea water conversion by otherwise eminent scientists.

In addition to American scientists it is my contention that the Senate should ask certain foreign scientists either to this present hearing or to a later one to be planned now. Among them should be Mr. C. H. Beau, the leading French expert on the thermal difference system, who has a vast amount of knowledge that is not shared by any American including myself although I was the first to visit the French in 1949 and last year spent months with them in Europe and am in constant correspondence with them, in their own language, up to this date. Also I believe certain Dutch and South African scientists should be called who have brought to greater perfection and lower costs of water than any American, the system promoted by the Ionics, Inc., in this country.

The above is written with the urgent hope that the hearings you are about to begin will be on a broad and genuinely scientific basis so they may lead us to construct the best possible demonstration plants based on our present stage of knowledge so that the taxpayers' money will give the returns that we have a right to expect.

Sincerely yours,

BRYN BEORSE.

LETTER FROM RICHARD A. HARVILL, PRESIDENT OF THE UNIVERSITY OF ARIZONA

UNIVERSITY OF ARIZONA,
OFFICE OF THE PRESIDENT,
Tucson, Ariz., March 13, 1958.

HON. CARL HAYDEN,
United States Senate, Washington, D. C.

DEAR SENATOR HAYDEN: I am sending under separate cover 50 copies of a report that has been prepared by Mr. Sol D. Resnick with reference to Senate Joint Resolution 135 which would authorize a full-scale saline water demonstration plant. I understand that hearings will be held on this matter on March 20–21.

A special statement by Mr. Resnick, hydrologist with the University of Arizona Agricultural Experiment Station, together with the basic information pertaining to the saline condition of the underground water and the agricultural resources, production and problems of the Safford, Graham County, area will support the general conclusion thta the Safford area would be a good one in which to locate the demonstration plant.

Perhaps a member of your office staff can get the material that I am sending to you to Senator Anderson for his Committee on Interior and Insular Affairs. The university is pleased to furnish this information.

Sincerely yours,

RICHARD A. HARVILL.

STATEMENT OF SOL D. RESNICK, HYDROLOGIST, UNIVERSITY OF ARIZONA

The Gila Valley around Safford (see fig. 1 for location) is an excellent site for the proposed United States Government plan for demineralization of brackish water for the following reasons:

1. The Gila Valley around Safford, which was first settled back in 1872 and now has a population of about 13,000 people, has 35,000 acres of land under irrigation. About 133,000 acre-feet of water is used for irrigation, of which about one-third or 43,000 acre-feet is diverted from surface water sources; mainly the Gila River which flows through the valley, and two-thirds or 90,000 acre-feet is obtained from 640 wells in the valley.

The salt content of the well water, for example, on the University of Arizona Experiment Station near Safford, varies from 2,148 to 4,091 parts per million (see table 2). Table 1 and figure 2 indicate that water containing a salt content over 2,100 parts per million is unsuitable for irrigation.

2. The practice of using surface water when available and well water as necessary enables the irrigators in the Safford area to obtain crops. However, the yearly agricultural income of about $6,200,000 (see table 5) is estimated to be from 20 to 25 percent, or about $1,500,000 lower than it should be due to the required use of brackish water for irrigation.

3. Federal ground-water authorities (see appendix) all agree that the highly mineralized ground water in the valley would ordinarily be considered unfit for irrigation and continued use may result in damage to cropland.

4. Cooperative research between personnel of the Agricultural Research Service, United States Department of Agriculture, and the departments of agricultural chemistry and soils and agronomy. University of Arizona, is being conducted to determine the effect of river and well water on soil structure, salt accumulation, and crop production at the Safford Experiment Station (see table 6). The research is pointed toward making the best of a bad situation; namely, obtaining maximum yields possible when brackish water is required in the irrigation program.

5. The University of Arizona Experiment Station near Safford would be an ideal location for the proposed plant as the brackish water problem on the farm is typical for the valley, university personnel could cooperate fully in the project, and pumping installations and required space would be available.

The officials of the Salt River Valley Water Users' Association feel that the field demonstration of the purification of brackish water conducted by Ionics, Inc., Cambridge, Mass., at an irrigation well site owned by the Buckeye Irrigation Co., Arizona, under the jurisdiction of the Office of Saline Water, United States Department of the Interior, and as reported in report No. 11, Office of Saline Water, was successful insofar as the salt content of the water was reduced from 4,000 to 250 parts per million. Water with 250 parts per million of total salts is, of course, excellent for irrigation. However, as expected, the water produced was too expensive for use in agriculture.

The Salt River Valley Water Users' Association officials further feel that full-scale trials using improved equipment should be tried, and they are in full agreement with the university regarding the proposal for a plant for Arizona.

Chemical analyses of water in wells on farms in the Gila Valley near Safford are given in tables 3 and 4.

FIGURE 1.—LOCATION OF GILA VALLEY AROUND SAFFORD, ARIZ.

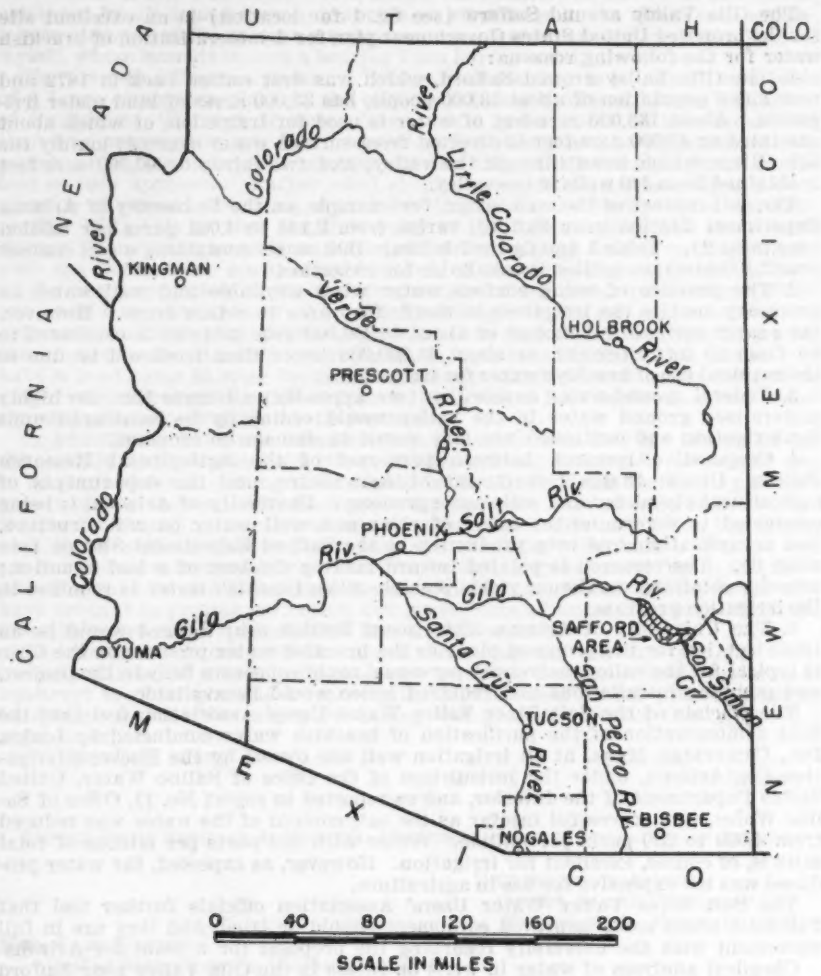


FIGURE 2.—DIAGRAM FOR USE IN INTERPRETING THE ANALYSIS OF AN IRRIGATION WATER

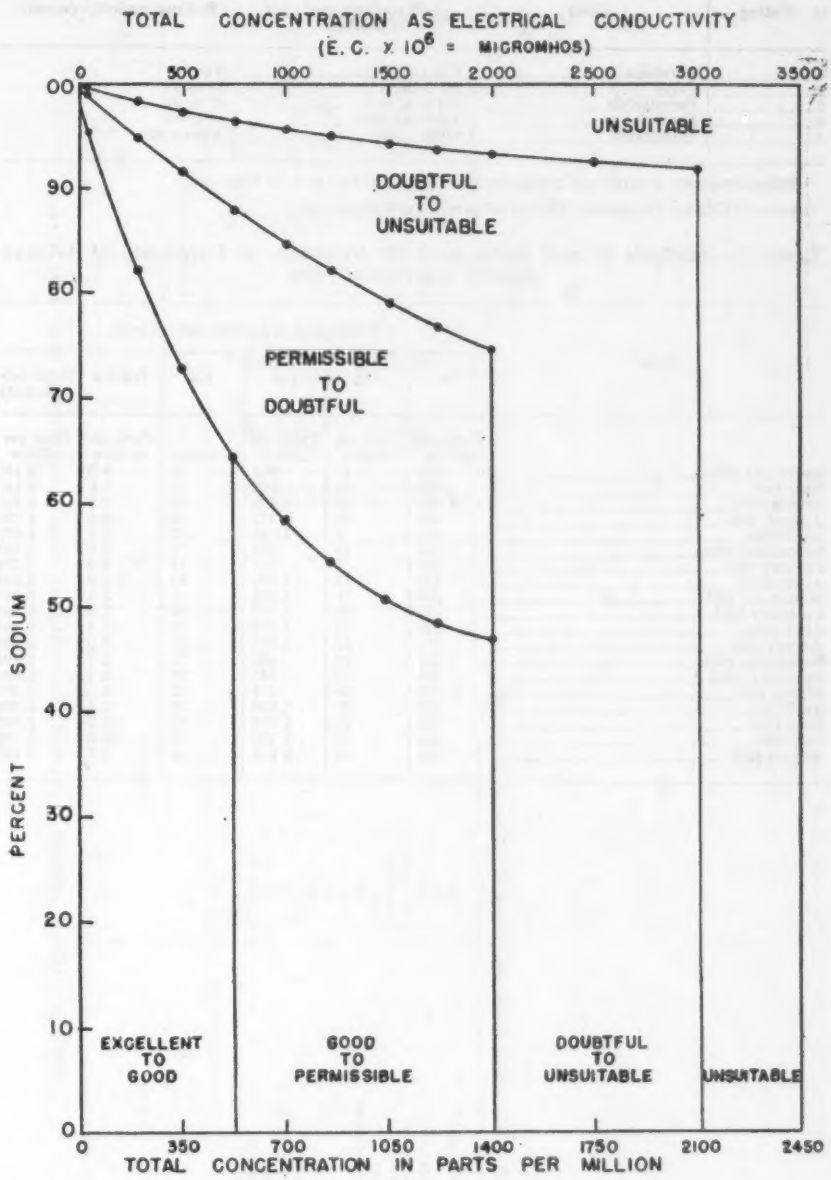


TABLE 1.—*Measuring quality of water*

Rating	Class	Salt content, parts per million	Sodium content,[1] percent
1	Excellent	0 to 175	0 to 20.
2	Good	175 to 525	20 to 40.
3	Permissible	524 to 1,400	40 to 60.
4	Doubtful	1,400 to 2,100	60 to 80.
5	Unsuitable	Over 2,100	Above 80.

[1] Sodium content: Sodium and potassium ions as a percentage of total basic ions.

Source: Table by Thorne and Thorne adapted from Wilcox, 1948.

TABLE 2.—*Analysis of well water used for irrigation at University of Arizona Safford experiment farm*

Date	University of Arizona station well					
	Ca	Mg	Na	Na	Na–Ca	Total soluble salts
	Parts per million	*Parts per million*	*Parts per million*	*Percent*	*Parts per million*	*Parts per million*
December 1945	120	17	575	81	4.8	2,148
June 1947	135	10	943	87	7.0	3,147
March 1948	187	15	1,403	87	7.5	3,957
August 1948	181	34	1,172	85	6.5	4,091
April 1949	167	4	1,150	87	6.7	3,671
November 1949	263	15	782	74	3.0	3,150
January 1950	225	7	575	71	2.6	2,273
April 1950	233	15	1,150	82	4.9	4,039
September 1951	339	11	1,058	75	3.1	4,085
February 1954	159	23	1,172	86	7.4	3,995
April 1954	120	12	1,058	89	8.8	3,364
August 1954	211	12	1,058	88	5.0	3,534
September 1954	126	43	460	73	3.7	2,721
February 1955	100	23	943	89	9.4	3,072
March 1955	153	39	851	82	5.6	3,071
April 1955	112	32	1,058	88	9.4	3,469
June 1955	110	22	1,128	89	10.2	3,647
July 1955	108	29	1,150	89	10.6	3,706
August 1955	159	19	1,058	86	6.7	3,558

TABLE 3.—*Recent (mostly 1957) analyses of ground water from Safford, Ariz., and vicinity*

Analysis No.	Owner	Location	Well depth (feet)	HCO_3	Cl	SO_4	Fl	Ca	Mg	Na	Na-Ca	Total soluble salts
				Parts per million								
69365	E. L. Moody	Thatcher		590	2,611	45		267	150	1,339	5.02	5,002
69432	M. H. Smithson	Safford		134	380	257	5.5	23	19	297	1.3	1,115
69725	T. P. Motes	do		276	2,057	782		258	32	1,449	5.6	4,854
69928	Mrs. Dorothy Roberts	do		156	202	248	1.4	21	6	271	12.9	905
69929	T. P. Motes	do		459	2,429	1,580	.4	640	206	1,366	2.1	6,680
69930	do	do		547	3,305	2,400	.8	621	239	2,314	3.7	9,427
69931	do	do		532	3,452	1,940	.2	755	232	2,042	2.7	8,953
69932	do	do		537	3,404	1,840	.1	781	219	1,964	2.5	8,745
69981	Mrs. Boyd Overton	do		83	92	232	1.4	48	2	140	2.9	597
68316	G. A. Taylor	Pima		573	900	480		142	91	699	4.9	2,885
68453	J. David Lee	Thatcher		715	1,580	1,000		146	50	1,518	10.4	5,009
68888	W. H. Van Order	Fort Thomas		573	3,600	780	1.5	394	232	2,050	5.2	7,629
68899	M. R. Bryce	do		473	2,420	1,100		516	126	1,425	2.8	6,090
68900	do	do		122	1,200	550		97	42	198	1.9	2,209
68901	W. H. Van Order	do		522	3,940	810		560	197	2,138	3.8	8,167

Source: Laboratory of department of chemistry and soils, University of Arizona.

23642—58——15

TABLE 4.—*Analyses of ground water from Safford, Ariz., and vicinity for the period 1944–48*

Analysis No.	Owner	Location	Well depth (feet)	HCO_3	Cl	SO_4	Fl	Ca	Mg	Na	Na-Ca	Total soluble salts
				Parts per million								
49163	Samuel F. Baird	Sec. 17, T. 8 S, R. 26 E		0	213	800	3.0	110	30	342	3.1	1,498
47915	Fred Clifford	Sec. 25, T. 7 S, R. 26 E	78	264	2,680	744	4.0	65	34	2,072	31.9	5,863
47965	do	Sec. 25, T. 7 S, R. 26 E		215	3,154	970	4.5	84	28	2,461	29.3	6,916
51331	W. M. Crum	T. 8 S, R. 25 E	855	97	620	175	3.5	22	8	488	21.0	1,414
51332	do	T. 7 S, R. 25 E	109	164	172	150	2.6	15	0	228	15.0	732
50236	Leslie Ellsworth	Sec. 36, T. 10 S, R. 28 E	1,700	217	220	450		15	8	409	27.0	1,319
51188	do	Sec. 36, T. 10 S, R. 28 E	1,700	180	194	185		15	4	216	14.4	794
51080	Farrell Evans	Sec. 17, T. 7 S, R. 26 E	91	464	640	375	1.7	98	11	637	6.5	2,226
51082	do	Sec. 8, T. 7 S., R. 26 E	84	525	980	300	1.8	157	22	754	4.8	2,742
49095	O. A. McNeeley	Sec. 32, T. 8 S., R. 26 E	33	208	124	124	5.2	25	2	194	7.8	682
51333	George E. Morris	Sec. 28, T. 7 S., R. 26 E	65	293	450	300	1.75	420	16	39	.09	1,520
51334	do	do	110	366	804	325		195	8	345	1.8	2,043
51335	do	Sec. 7, T. 8 S., R. 26 E	1,190	83	680	275	2.9	52	4	536	10.0	1,633
51336	do	do	1,090	76	708	300	3.2	15	4	428	29.0	1,570
51337	do	do	790	215	54	275	3.75	8	4	55	7.0	615
51338	do	do	1,000	161	320	300	3.3	15	8	359	24.0	1,173
51339	do	do	800	73	594	300	4.75	8	2	155	20.0	1,186
	E. W. Richardson	Sec. 32, T.7 S., R.26 E	90	76	4,550	425	0.85	368	146	2,208	6.0	7,773
46107	Municipal utility	Bonita Creek		250	14	10	.45	44	15	35	.8	374
	Water supply	do		280	47	5	.4	70	15	33	.47	458
46259	do	Sec. 6, T.6 S., R.28 E		260	14	T	.4	35	27	17	.48	353
51329	Scott	T.7 S., R.25 E	1,300	49	140	200	4.2	120	4	60	.5	627
51330	do	do	1,245	59	1,110	250	4.2	98	11	731	7.5	2,263
53455	N. W. Stevenson	Sec. 6, T.7 S., R.26 E	80	453	581	202	1.6	188	4	439	2.3	1,874
47168	University of Arizona farm	Sec. 12, T. 7 S., R. 26 E		521	611	320		91	8	631	6.9	2,182
53442	do	do		1,220	1,360	459	3.6	278	0	1,242	5.0	4,563
47169	do	Sec. 7, T. 7 S., R. 26 E		469	443	148		182	35	261	1.4	1,538
47980	do	Sec. 22, T. 7 S., R. 26 E		534	646	261	1.8	121	17	585	4.8	2,181
51102	do	do		620	1,350	375	1.85	187	15	1,409	7.5	3,957
52931	Norman Carpenter	Sec. 3, T. 7 S., R.27 E	500	124	304	268	6	30	0	336	11.0	1,069
52930	Rider Ridgeway	Sec. 17, T. 8, R. 26	1,524	98	52	300	9	30	0	179	6.0	669
52136	Municipal utility	T.7 S., R.25 E		190	860	400	.9	533	23	2	0	1,648
51617	Woods	Thatcher		173	430	550	.8	510	8	10	.02	1,681
52638	Orrin Ferrin	do		166	820	300	2.5	8	4	704	87.0	2,005
52635	do	do		122	156	175	2.9	8	4	216	27.0	685
52636	do	do		61	1,460	210	2.9	83	8	966	12.0	2,793
52637	do	do		24	1,180	235	2.1	83	8	782	9.5	2,314
52639	do	do		78	980	230	2.2	53	11	699	13.0	2,056

Source: University of Arizona Agricultural Experiment Station Bull. 225, November 1949.

TABLE 5.—*Estimate, by Department of Agricultural Economics, University of Arizona, of value of agricultural products in Graham County for 1956*

Item	*Value*
Cotton lint and cottonseed	$4,212,000
Cattle and calves	580,000
Lettuce and other vegetable crops	67,000
Grains, commercial feed	373,000
Dairy products	774,000
Alfalfa and other hays	396,000
Sheep, lamb, and wool	---
Citrus fruits	---
Eggs, chickens and turkeys	63,000
Seed crop	48,000
Miscellaneous crops, including wheat and grapes	64,000
Miscellaneous livestock and livestock products	134,000
Federal Government payments	73,000
Total	6,803,000

NOTE.—About 90 percent of the production in Graham County estimated to be in the Safford area.

TABLE 6.—RESEARCH PROJECT AT SAFFORD EXPERIMENT STATION

UNIVERSITY OF ARIZONA AGRICULTURAL EXPERIMENT STATION

Department: Agricultural chemistry and soils, and agronomy and range management.

Project title: The effect of irrigation practice on salt accumulation and crop production.

Subproject: Effect of river and well water on soil structure, salt accumulatoin, and crop production at the Safford Experimental Station.

Personnel: W. H. Fuller, D. F. McAlister, Karl Harris, and Leonard Erie.

Funds: State research and regional research.

Location and acreage: Safford Experiment Station, field D, border 1 to 36.

Objectives: To compare the influence of well water and river water on crop establishment, yield, salt accumulation, and physical properties of the soil.

Procedure and materials: (Outline procedure here; detailed schedule may be appended on separate sheet; notes and records to be taken).

The overall procedure will involve the use of combinations of well and river water in an attempt to maintain maximum crop production. In addition, an attempt will be made to evaluate the basic soil and water factors which control seedling emergence, stand, and crop yield. Such physical properties as water infiltration rate, bulk, density, modulus of rupture and chemical properties as total salt accumulation, total exchangeable sodium content will be evaluated in relation to the soil and water management treatments. Crop studies will include the determination of seedling emergence, stand, and yield.

The individual treatments will be as follows:

1. River water as necessary for growing the crop (cotton); supplemented by well water if necessary. One acre-foot river water applied in the preplanting irrigation.

2. River water as necessary for growing the crop; supplemented by well water if necessary. Two leachings with river water, 1 acre-foot each, one immediately after cotton harvest and one at the time of the preplanting irrigation.

3. Well water as often as necessary for growing the cotton crops; one leaching of an acre-foot of well water applied as the preplanting irrigation.

4. Well water as often as necessary for growing the cotton crop. Two leachings with well water, 1 acre-foot each, one immediately after cotton harvest and one at the time of the preplanting irrigation.

5. Well water as often as necessary for growing the cotton crop. One leaching (1 acre-foot of water) with river water as the preplanting irrigation.

6. Well water as often as necessary for growing the crop. Two leachings with river water, 1 acre-foot each, one immediately after cotton harvest and one at the time of the preplanting irrigation.

Field layout—Safford Experiment Station, field D

Title of experiment		Kind of water for crop irrigation	Number of leachings	Kind of leaching water	Replications
Border No.	Treatment No.				
1	1	River	1	River	1
2	2	do	2	do	
3	3	Well	1	Well	
4	4	do	2	do	
5	5	do	1	River	
6	6	do	2	do	
7	2	River	2	do	2
8	3	Well	1	Well	
9	6	do	2	River	
10	1	River	1	do	
11	4	Well	2	Well	
12	5	do	1	River	
13	3	do	1	Well	3
14	6	do	2	River	
15	2	River	2	do	
16	5	Well	1	do	
17	1	River	1	do	
18	4	Well	2	Well	
19	4	do	2	do	4
20	5	do	1	River	
21	1	River	1	do	
22	2	do	2	do	
23	6	Well	2	do	
24	3	do	1	Well	5
25	5	do	1	River	
26	1	River	1	do	
27	4	Well	2	Well	
28	6	do	2	River	
29	3	do	1	Well	
30	2	River	2	River	
31	6	Well	2	do	6
32	4	do	2	Well	
33	5	do	1	River	
34	3	do	1	Well	
35	2	River	2	River	
36	1	do	1	do	

Appendix 1

History of Research Regarding Quality of Water in Safford Area

During the past 20 years or more, the chemical quality of available waters in the Safford Valley has been the subject of investigations by several Federal and State organizations. The more comprehensive publications on water resources and quality in Safford Valley are listed in the references. Analyses of 49 ground-water samples collected in 1933–34 in the Safford-San Simon area were reported by Knechtel (1938). During the period 1940–44, more than 4,000 samples were collected in Safford Valley; their analyses were presented by Hein (1950), who observed that ground water from recent alluvium in the valley (between Solomonsville gaging station and Calva) contained total dissolved solids ranging from less than 500 to more than 10,000 parts per million, and that water from the deeper Tertiary and Pleistocene Valley fill contained commonly more than 1,000 and in places more than 14,000 p. p. h. of dissolved solids.

Also, in 1943–44, the Water Resources Division of the United States Geological Survey made an intensive study (using chemical methods in part) of use of water by vegetation in the valley (Gatewood and others, 1950). Analyses of nearly 1,000 ground-water samples were tabulated by Morrison and others (1942). Analyses of 36 samples from the Safford-Thatcher area, published by Smith and others (1949) are tabulated in table 4.

Statements by several workers, regarding quality of water in the region, are as follows:

(1) Knechtel, 1938, page 218: "The 49 (water) samples examined are mainly sodium chloride, sodium carbonate, and sodium sulfate waters and are rather highly mineralized * * *. Sodium is the chief basic constituent of 46 of the waters. Chloride is the main acid constituent in 32 of the samples, carbonate in 12, and sulfate in 5. The concentration of these 3 acid constitutes is rather high in nearly all the waters."

(2) Turner, 1946: "Most of the ground waters of the basin are classified as 'good to injurious' or 'injurious to unsatisfactory' for irrigation because of their dissolved matter. If waters of these classifications are used for irrigation, they should be used with caution, to avoid damage to soils, and crops."

(3) Hem, 1950, page 3: "Much of the ground water pumped in the Safford Valley is so highly mineralized that it would ordinarily be considered unfit for irrigation, and the continued use of large amounts of highly mineralized ground water in the valley may result in damage to cropland."

(4) Feth in Halpenny and others, 1952, pages 51–52: "The chemical quality of waters in the Safford Basin constitutes one of the major problems of water supply in the region."

Appendix 2

History of Development and Extent of Irrigated Acreage in Safford Area

Irrigation in Safford Valley was begun about 1872 by Mexican immigrants and Mormon pioneers, using diversions from the Gila River. By 1899, about 20,000 acres were under irrigation (Newell, 1901). Acreage increased until about 1920, and remained fairly constant thereafter at about 32,000 acres. Estimates of the number of acres under irrigation in Graham County for the years 1940–57 have been published in bulletins of the agricultural experiment station, University of Arizona, and are tabulated on a table shown below. Essentially all of this acreage is in the Safford Valley.

Irrigated crop acreage for Graham County

Year:	*Acres*	Year—Continued	*Acres*
1940	33,000	1949	35,000
1941	33,000	1950	35,000
1942	33,000	1951	33,500
1943	33,000	1952	36,140
1944	33,000	1953	42,000
1945	35,000	1954	35,000
1946	35,000	1955	35,000
1947	35,000	1956	35,000
1948	35,000	1957	32,000

Source: University of Arizona Experiment Station bulletins.

Appendix 3

History of Irrigation Wells in Safford Area

Drilling of irrigation wells in Safford Valley was begun about 1938. By the end of 1940, about 150 irrigation wells had been drilled, of which 120 were active (Gatewood and others, 1950, p. 8). By 1944 there were 215 active wells from which between one-third and one-fourth of the total irrigation water was being pumped (Halpenny and others, 1952, page 64; 66). In the summer of 1952, there were about 580 active wells, and in 1957 about 640 wells.

The ground water, which is generally highly mineralized, either is used for an occasional supplemental irrigation, or is mixed with river water of better chemical quality. During drought years, such as some years between 1946 and 1953, the quality of water problem for irrigation is accentuated because the mineralization of ground water in the recent alluvium is closely associated with runoff in the Gila River. When runoff is high, the ground-water reservoir is recharged largely from river water which is relatively low in dissolved mineral matter; however, when runoff is low, a greater proportion of ground-water recharge is from highly mineralized infiltration from canals and irrigated fields. In addition, the drier years demand more ground-water pumpage, as indicated by the increased number of wells drilled without a corresponding increase in irrigated acreage.

The annual amounts of water withdrawn for irrigation from ground-water pumpage and surface-water diversions during the period 1940–56 are tabulated on following page.

APPENDIX 4

Diversions in acre-feet for Safford area

Year	Ground-water pumpage	Surface-water diversions	Total	Year	Ground-water pumpage	Surface-water diversions	Total
1940	24,600	99,693	124,293	1949	40,000	167,790	207,790
1941	8,685	151,300	159,985	1950	90,000	68,504	158,504
1942	18,900	172,005	190,905	1951	125,000	26,400	151,400
1943	35,000	121,569	156,569	1952	[1] 70,000	129,500	199,500
1944	52,000	128,027	180,027	1953	[1] 120,000	39,300	159,300
1945	35,000	148,675	183,675	1954	[1] 90,000	80,200	170,200
1946	115,000	69,909	184,909	1955	[1] 90,000	86,000	176,000
1947	100,000	51,978	151,978	1956	[1] 90,000	42,800	132,800
1948	110,000	39,848	149,848				

[1] Approximate figures from Halpenny and others, 1952, and records of the Ground Water Branch, USGS.

REFERENCES

A. Partial list of publications dealing with water resources and chemical quality of waters of Safford Valley, Ariz.

1. Cushman, R. L., and Halpenny, L. C., Effect of Western Drought on the Water Resources of Safford Valley, Ariz., 1940–52: Trans. Am. Geophysical Union, volume 36, No. 1.

2. Gatewood, J. S., and others, 1950, Use of Water by Bottom-Land Vegetation in Lower Safford Valley, Ariz.: United States Geological Survey Water-Supply Paper 1103.

3. Halpenny, L. C., and others, 1952, Ground Water in the Gila River Basin and Adjacent Areas, Arizona—A Summary: United State Geological Survey Open-Fle Report.

4. Hem, J. D., 1950, Quality of Water of the Gila River Basin above Coolidge Dam, Ariz.: United States Geological Survey Water-Supply Paper 1104.

5. Knechtel, M. M., 1938, Geology and Ground-Water Resources of the Valley of Gila River and San Simon Creek, Graham County, Ariz.: United States Geological Survey Water-Supply Paper 796–F.

6. Newell, F. H., 1901, Report of Progress of Stream Measurements for the Calendar Year 1899: United States Geological Survey, 21st Anniversary Report, Part 4.

7. Smith, H. V., Caster, A. B., Fuller, W. H. Breazeale, E. L., and Draper, G., 1949, The Chemical Composition of Representative Arizona Waters: University of Arizona, Agricultural Experiment Station Bulletin 225.

B. Unpublished reports

1. Morrison, R. B., McDonald, H. R., and Stuart, W. T., 1942, Records of Wells and Springs, Well Logs, Water Analyses, and Map of Safford Valley, Graham County, Arizona: United States Geological Survey typewritten report, 102 pages.

2. Turner, S. F., and others, 1946, Ground-Water Resources and Problems of the Safford Basin, Arizona: United States Geological Survey typewritten report, 28 pages.

(Senator Anderson subsequently ordered the following letters to be printed:)

LETTER FROM THE SOUTHWEST WATER LEAGUE, LOS ANGELES, CALIF.

THE SOUTHWEST WATER LEAGUE,
Los Angeles, Calif., April 10, 1958.

Re sea water conversion

Hon. CLINTON P. ANDERSON,
Senator From New Mexico,
Washington, D. C.

DEAR SENATOR ANDERSON: As the chairman of the subcommittee on Irrigation and Reclamation, you will be interested in some factual data relating to the cost of Colorado River water for the city of Los Angeles since the Metropoliton Water District aqueduct was completed in 1941.

Water officials of Los Angeles say that water from the Colorado River costs us only $20 an acre-foot, the sum paid by the city water bureau to the Metropolitan Water District. The aqueduct to the Colorado River cost $220 million. Down to June 30, 1956, taxes were levied on Los Angeles property in the huge sum of $144,739,953, and on property within the Metropoliton Water District taxes levied were $254,325,691 to pay interest and principal on the bonds, with an unpaid portion on the bonds being $186 million.

Spreading the cost per acre-foot used by Los Angeles from 1941 through to June 30, 1954, with $20 per acre-foot paid by the local water bureau to the Metropolitan Water District, plus $1,220 taken from taxes, equals $1,240 per acre-foot. Down to June 30, 1956, with increased consumption the last 2 years of that period, the cost is $955 an acre-foot. Our city controller confirmed my belief that, with increased consumption to full capacity of our city's allotment from the Colorado River, it will be at least 100 years before the cost per acre-foot can possible be brought down to figures now used by the local water board; and by that time we will be able to rent our outmoded 300-mile Colorado River aqueduct to Walt Disney for "Tours with Alice to Waterland."

The facts presented herein (down to June 30, 1954) were included in my testimony at the hearings before the special subcommittee of the Committee on Government Operations in the House of Representatives, December 8, 1955; and I hereby grant you the privilege of entering the contents of this letter in the report of your recent hearings relating to the cost of sea water conversion for domestic and other uses.

As president of the Southwest Water League embracing 48 cities in southern California I have been active in proposing conversion of sea water for domestic use. I urge your committee to recommend construction of a test plant on our California coast where the need is greatest.

Sincerely yours,

ANDRAE B. NORDSKOG, *President.*

LETTER FROM THE NATIONAL SCIENCE FOUNDATION

OFFICE OF THE DIRECTOR,
Washington, D. C., April 21, 1958.

Hon. JAMES E. MURRAY,
Chairman, Committee on Interior and Insular Affairs,
United States Senate, Washington, D. C.

MY DEAR SENATOR MURRAY: This is in reply to your recent letter requesting the comments of the National Science Foundation on Senate Joint Resolution 135, providing for the construction of a full-scale demonstration plant for the desalination of sea water.

The possibilities inherent in practical desalination of sea water are extremely important both in the United States and abroad. We are familiar with the program of the Department of the Interior in this field and believe that it should be encouraged.

It is our understanding, howeevr, that to date, no process has been found which is capable of utilizing a full-scale demonstration plant in this country which would provide water at competitive cost. Under such circumstances, eventual progress with regard to practical desalination of sea water would probably be more effectively furthered by research and pilot plant operation rather than by building a demonstration plant.

Thank you for giving us the opportunity to comment on the bill.

The Bureau of the Budget has advised us it has no objection to the submission of this report.

Sincerely yours,

ALAN T. WATERMAN, *Director.*

LETTER FROM THE DEPARTMENT OF WATER RESOURCES, CALIFORNIA

SACRAMENTO, *April 25, 1958.*

Hon. CLINTON P. ANDERSON,
Chairman, Subcommittee on Irrigation and Reclamation,
United States Senate Committee on Interior and Insular Affairs,
Senate Office Building, Washington, D. C.

DEAR SENATOR ANDERSON: Transmitted herewith is a copy of Assembly Joint Resolution No. 11, introduced by Assemblyman Jack Beaver of San Bernardino

and passed by the Legislature of the State of California, pertaining to cooperation by the State with the Federal Government in saline water conversion research and operation of demonstration plants. We hope that the action of the California State Legislature will be of interest to you and your committee in considering the Federal program.

Sincerely,

HARVEY O. BANKS, *Director.*

RELATIVE TO CONSTRUCTION OF A SALT WATER CONVERSION DEMONSTRATION PLANT

Whereas the United States Department of the Interior has been conducting research and studies in the field of conversion of sea water; and

Whereas the Departmentof Water Resources of the State of California and the University of California are pursuing programs of investigation and study of sea water conversion; and

Whereas it is recognized that the development of a practical process for conversion of sea water would result in large savings to federal, state, and local agencies and have a beneficial effect on the economy of the Nation and the State; and

Whereas several bills have been introduced in Congress including H. R. 10606, H. R. 11405, and H. J. Res. 541 authorizing the Secretary of the Interior to enter into an agreement with the State of California providing for the construction and operation of a full-scale salt water conversion plant in California on a cooperative basis; and

Whereas the construction and operation of a demonstration plant is essential to the development of reliable design criteria and cost data; and

Whereas construction and operation of a demonstration plant in California would be beneficial to this State; and

Whereas committees of the Congress are holding hearings on bills authorizing construction and operation of such demonstration plants; now, therefore, be it

Resolved by the Assembly and Senate of the State of California, jointly, That it is the intent of the Legislature of California to cooperate financially and otherwise with the Federal Government in developing processes for saline water conversion including the construction and operation of demonstration plants, and to coordinate the programs of the State in the field of sea water conversion with the programs of agencies of the Federal Government; and be it further

Resolved, That Mr. Harvey O. Banks, Director of Water Resources, shall appear before appropriate committees of Congress to present the views of the State of California as expressed herein; and be it further

Resolved, That the Legislature of the State of California respectfully memorializes the Congress of the United States to authorize the Secretary of the Interior to construct a full-scale salt water conversion demonstration plant in California in cooperation with the State of California; and be it further

Resolved, That the Chief Clerk of the Assembly be hereby directed to transmit copies of this resolution to the President and Vice President of the United States, to the Speaker of the House of Representatives, and to each Senator and Representative from California in the Congress of the United States.

LETTER FROM OSCAR CHAPMAN

CHAPMAN, WOLFSOHN & FRIEDMAN,
Washington, D. C., March 25, 1958.

Hon. CLINTON P. ANDERSON,
Chairman, Subcommittee on Irrigation and Reclamation,
United States Senate, Senate Office Building, Washington, D. C.

DEAR CLINT: I regret that an out-of-town engagement deprived me of an opportunity to appear last week in support of the implementation of the saline water program in the Department of the Interior as proposed in your Senate Joint Resolution 135 and S. 3370, sponsored by Senator Case, of South Dakota.

The saline water conversion program, which was gotten under way in 1952, when I was Secretary of the Interior, was a nonpartisan approach to a phase of the national water problem that compares in importance with President Theodore Roosevelt's support of the reclamation law, sponsored by Senator Francis

G. Newlands, of Nevada, in 1902. It was reassuring to read in press reports of the active participation in the hearings of Senator Kuchel, of California, and that Senator Knowland, the Republican leader of the Senate, had sent a letter endorsing your proposed program. The saline water approach should be kept on a nonpartisan basis as I know you intend to do.

It is good to see that Representative Clair Engle, of California, is taking the leadership in the House in behalf of a truly effective saline water program. He was largely instrumental in that body in getting the program off the ground in 1952. The interest shown by his colleagues—Representatives Roosevelt, Holifield, King, and Wilson, of California, who have sponsored companion measures in the House, is gratifying.

There is a growing need for water for domestic and industrial purposes. Ever-increasing population is a major, but only one, factor in this demand. The simple fact is that the boundary of the semiarid area is moving eastward and thus we have startingly become aware in the last several years that water is a problem not lone in the West, but also in the eastern half of the country.

Looking ahead in the water situation is thus, I would think, not merely desirable but essential and practically mandatory on the leaders of our Nation.

My suggestion to you and the other sponsors of an action program is to authorize demonstration plants of adequate capacity at 1, 2, or 3 points on the California, gulf, or Atlantic coasts for desalting sea water. At the same time, a comparable number of demonstration plants for the treatment of brackish water in the Great Plains and other areas should be authorized. These plants need not be of maximum capacity, but certainly should be beyond the pilot plant stage. After 5 years of preparatory work, we must certainly be at a point where our professional experts and industrialists are in a position to engineer demonstration plants in both fields that will achieve results.

Please accept my congratulations on your leadership in this and other fields, a leadership which is most inspiring.

With best wishes,

Sincerely,

OSCAR CHAPMAN.

UNITED STATES SENATE,
Washington, D. C., April 2, 1958.

Mr. OSCAR CHAPMAN,
Chapman, Wolfsohn & Friedman,
Pennsylvania Building, Washington, D. C.

DEAR OSCAR: I was happy to have your letter of March 25. I am sorry you could not attend the hearings on the saline water bill. We hope to get it reported soon so that we may have action on it during this session.

I appreciate having your observations and the kind remarks in your letter.

Sincerely yours,

CLINTON P. ANDERSON.

Senator CASE. If there is nothing further, the committee stands adjourned.

(Whereupon, at 3:45 p. m., the committee adjourned.)

×